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SERIES

GLASS AND GLASSWARE

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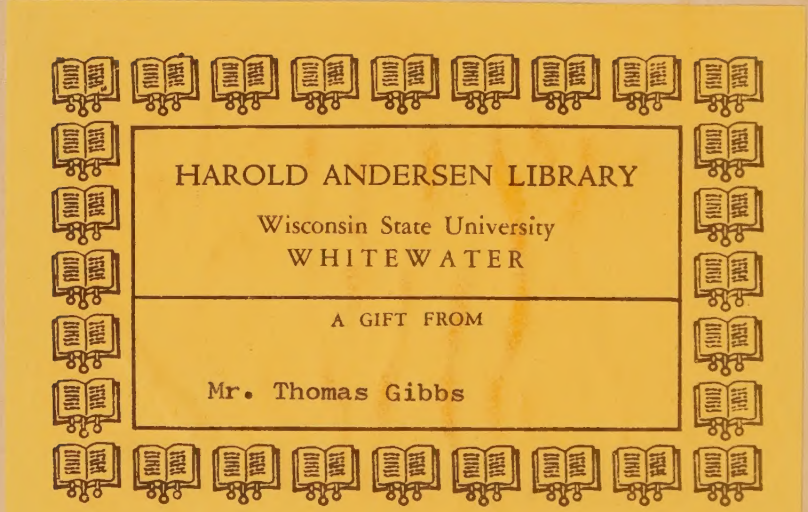

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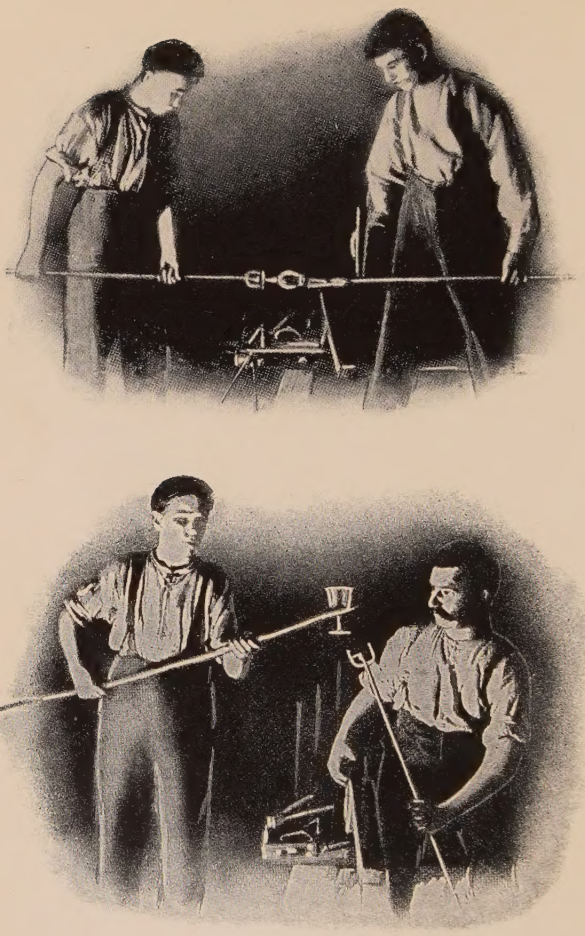

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Forming the Stem of a Goblet (upper)
Finished Goblet Ready for Annealing (lower)

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MERCHANDISE MANUAL SERIES

GLASS AND GLASSWARE

BY

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This Series is Dedicated

to Mrs. Henry Ollesheimer, Miss Virginia Potter, and Miss Anne Morgan, who desiring to give greater opportunity for advancement to commercial employees and believing that all business efficiency must rest upon a solid foundation of training and education gave years of enthusiastic service to the testing of this belief.

ACCESSION NO

MERCHANDISE MANUAL SERIES

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EDITOR'S PREFACE

As "Department Store Merchandise Manuals" these books were originally written for salespeople and were designed to give them reliable information concerning the sources and manufacturing processes of the merchandise which they handle. When it was necessary to deal with scientific or historical material it was treated as simply and concretely as possible and the point of view taken was that of business rather than that of the school or laboratory. In this form they have proved their practical value not only to the department store salesperson but in the specialty shop. It has been pointed out, however, that the material has a wider scope than that of sales manuals alone.

As reference books, librarians will find the short, clear statements and full indexes invaluable.

As an encyclopædia of merchandise the series contains scientific information in a simple, compact form which makes it available for children and others to whom the subjects treated are unfamiliar.

As textbooks they are adapted for use in commercial schools, high schools, night schools, settlement classes, and by teachers of household arts and domestic science.

As source books for practical story-telling, kindergartners, primary and vacation school teachers will find in them an abundance of interesting material for short "true" stories on the various industries and crafts, the manufacture of household articles, such as pins and needles, as well as the making of pottery, glass, and steel. These manuals contain just the material often hunted for in vain by teachers and librarians.

As household helps and shopping guides the young housekeeper will find the manuals her best friends because they not only describe the manufacturing processes but tell her how to distinguish well-made articles of good materials from the inferior and badly made. They also tell her how to care for the clothing or household goods which she has bought.

For salespeople and storekeepers they supply the general and specific information about their merchandise which is indispensable to efficiency, yet very hard to gather from the scattered sources upon which they now depend.

These changes should enlarge the usefulness of the manuals without losing any of their specific value in the field of salesmanship.

We wish to express our grateful appreciation to the manufacturers and experts who have given us such valuable counsel and cordial co-operation.

BEULAH ELFRETH KENNARD.

AUTHORS' PREFACE

Glass is among the major forms of merchandise. It enters into so many of the articles commonly used in the household that it is practically an indispensable material. In table and kitchenware, in toilet articles and in ornaments, for mirrors and for windows, glass is found to be either the best substance for the purpose, or in many cases the only one that will serve. A knowledge of its sources, manufacture, and qualities is as valuable and interesting as a knowledge of textiles. If one is buying or selling glass, such knowledge is necessary for efficiency, but the student of chemistry, electricity, or applied science, and the artistic craftsman will find it equally important in his work.

In order to touch upon some of the uses of glass outside of the Glassware Department, but of prime importance and interest to the student and general reader, a section devoted to lamps, windows, stained glass, and optical glass has been added.

The authors are indebted to Mr. Frank E. Freese of the United States Glass Co. for reviewing the section on manufacture of glass; to Mr. E. W. Bryce,

Superintendent of Factory B, United States Glass Co., for valuable notes on manufacture; to Mr. A. Douglas Nash, Secretary, Treasurer, and Assistant Manager of the Tiffany Furnaces, for reviewing the chapter on Tiffany glass and contributing the section on peacock glass; to C. Dorflinger & Sons and to Mr. G. M. Jaques of *The Crockery and Glass Journal* for reviewing the parts on tableware and cut glass; to L. Solomon & Son for reviewing the chapter on silver deposit ware; to Mr. Howard J. Wilbert of the Pittsburgh Art Glass Co. and to Mr. Charles J. Connick of Boston, for most valuable assistance and criticism and for the illustrations of windows and stained glass; and to Mr. E. Y. Davidson, of the Macbeth-Evans Glass Co., for reviewing the chapter on "Lamps and Lampshades" and adding the material on daylight glass.

For illustrations thanks are due to C. Dorflinger & Sons, United States Glass Co., A. Gredelue, and to Pittsburgh Art Glass Co.

Helen Mary Lehmann.
Beulah Elfreth Kennard.

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GLASS AND GLASSWARE

Chapter I

THE GLASSWARE DEPARTMENT

Effective Display

One of the most beautiful and effective displays of the modern store is found in the Glassware Department. It is sometimes situated where the natural light is strong; but more often it is lighted artificially with an arrangement of mirrors and reflectors to give the most brilliant and dazzling effect.

Glassware is placed on glass shelves — often mirrors with mirror backgrounds — on polished tables, or on velvet or felt. Sets are arranged on mirror plateaux which give them a double reflection.

Colored glass is grouped harmoniously; a few pieces are often introduced among the crystal to heighten the beauty of each by contrast. The decorations in

gold, silver, and enamel are brilliant and glistening and add to the effect of splendor.

Divisions of the Glassware Department

There are usually three general divisions of the Glassware Department:

1. Tableware
2. Toilet sets
3. Decorative or art glass

Sometimes a division is made between the domestic and the imported glass; but the American glass is so excellent in quality that there is no need for such a distinction.

Glass is also divided according to its composition, into:

Flint, lead, or crystal glass
Lime or lime-crystal glass
Common or bottle-glass

Manufacturers are known as flint or lime manufacturers, according to the kind of glass they produce.

Cut glass is made of lead or flint glass and is sometimes called cut rock crystal; pressed or molded glass is lime-crystal; and the cheaper grades may be bottle-glass.

Glass is also referred to commercially as American,

Belgian, Bohemian, Swedish, French, or English, indicating the country in which it was made; and in other cases it may be referred to by the name of the manufacturer.

Characteristics of Glass

Glass is one of the most valuable of all manufactured materials. It has the three most essential qualities:

Utility
Durability
Beauty

Utility

The usefulness of glass is primarily due to its great adaptability. As a container of food it is almost perfect, as it can be attacked by only one acid and that acid is not found in food. It is, however, slightly affected by strong alkalies.

Because of its smooth surface it can be kept clean and will not retain odors; and thus it makes the best possible container for liquids, medicines, and nearly all chemicals.

Because of its transparency it is the best material for windows, lamp chimneys, shades, and all illuminating fixtures.

Its use in photography, astronomy, and all the phys-

ical sciences is unequaled, and it is the one material which can preserve and aid the sight.

Durability

The durability of glass is not generally realized. It is brittle, of course, and may be fractured by a blow or by too sudden expansion or contraction caused by sudden applications of heat or cold. On the other hand, ordinary usage does not wear it out and the atmosphere does not disintegrate it.

Its durability is largely dependent upon careful annealing, which is one of the finishing processes.

Beauty

The transparency and the refraction of light by colorless glass makes it beautiful. This beauty may be increased by cutting, polishing, and other modes of decoration and by the addition of color. The dazzling beauty of artistic glass almost equals that of perfect gems.

Part I—Manufacture of Glass

Chapter II

GLASS MATERIALS

Nature and Composition

Glass is an artificial substance of mineral composition. It has some of the characteristics of metals and some of those of the non-metallic minerals. It resembles metals in that it may be molded or drawn out into thin threads or tubes when heated to a certain temperature; but it is far more brittle. When heated, glass becomes viscous; that is, in a condition between that of a liquid and that of a true solid; when cool, the materials of which it is composed are held together in solution but not actually united.

Under ordinary conditions glass is transparent, though it may readily be made so that one cannot see through it. It might easily be mistaken for those natural mineral formations which we call precious stones, except that it never crystallizes.

Difference Between Precious Stones and Glass

All transparent minerals, and many which are not transparent, have a crystalline formation — that is, the tiny particles of which they are composed are grouped in regular geometrical figures. These figures may be too small to be seen without a microscope; but they are always there, and it is the reflection of light from these tiny particles that makes polished stones used in jewelry more beautiful than glass. Glass has none of these tiny crystals.

Materials of Which Glass Is Composed

Glass contains:

Sand or silica
Lime
Lead or flint
Soda or potash

It may also contain metallic oxides for coloring matter and frequently other metals, such as aluminum, iron, zinc, magnesium, barium, borax, arsenic, and antimony.

Glass containing a number of different materials melts at a lower temperature, but is less perfect in structure, than that composed of pure silica, lime, and soda; or silica, lead, and potash. These materials mixed together form what is called the "batch," that

is, the mixture which, when sufficient heat is applied, becomes glass.

Sand

As clay is the main element in all pottery, so is sand the essential material in the making of glass. No glass can be made without it. It contributes toughness and strength to the batch and the viscosity which makes it possible to shape the molten glass into proper form.

In an elementary class in chemistry, experiments in which acids and alkalies combine are often shown early in the course. The instructor perhaps pours hydrochloric acid into a dish containing soda, and the students observe the violent boiling and bubbling that follows. This is known as a chemical reaction. After things quiet down and evaporation takes place, the dish contains a substance neither acid nor soda, but a neutral compound formed by the union of the chlorin of the acid with the sodium of the soda, which proves to be sodium chlorid, or common salt.

A similar happening takes place in the making of glass. An acid is generally thought of as a liquid with a sour taste and pungent odor, and it may seem an absurd statement to say that sand is an acid. Nevertheless from a chemical standpoint the statement is true. When the sand is mixed with the soda and lime

the high temperature of the furnace is all that is needed to bring about just such a reaction as occurs when hydrochloric acid and soda are brought together. The resulting compound, glass, is therefore a neutral salt (silicate of sodium and calcium), although its properties differ greatly from other salts.

Occurrence of Sand

Sand in one of its various forms exists everywhere. It is formed by the wearing away of rocks by wind, rain, snow, and other forces of nature. It is finally deposited in a pure state in sea, river, or lake beds, and in a less pure state in the sandy soils of certain districts. What is called " sand " may be almost anything from nearly pure silica (sand that is 99.9 per cent pure) down to clay marls, a crumbling deposit consisting chiefly of clay mixed with limestone, which contains very little silica.

Quality of Sand Depends on Constituents

The quality of sand is largely determined by the amount of other substances it contains, such as compounds of iron, lime, aluminum, and magnesium. If pure it is perfectly white and does not effervesce or change color when treated with an acid. It is insoluble in all acids except hydrofluoric.

The value of sand is largely determined by the

amount of iron it contains, because iron gives glass a greenish-yellow or clouded appearance. As nearly all sand contains some iron, cobalt or manganese is usually added to neutralize the undesirable color.

The sand used in making the best grades of glassware must be free from impurities, fine, and of uniform quality. If the sand is too coarse it will not fuse quickly, and if it is too fine it will melt too rapidly.

Sand Beds

The most desirable sand is usually found on the seashore or in the beds of rivers or lakes, where the grains are ground to a uniform size and shape by the constant friction of the water.

Two famous sources are the Forest of Fontainebleau near Paris and Alum Bay in the Isle of Wight. Epinal, Belgium, has sand of almost equally pure composition. English sands are not of such high quality.

Most of the sand in the United States is tinged with yellow or gray. Practically every state in the Union contains sand fit for glass. The most important deposits in the country, however, are located in West Virginia, Massachusetts, Pennsylvania, and Illinois. Sand from the Berkshires in Massachusetts is practically free from iron, and that from Pennsylvania contains less than .01 per cent. The finest quality is found in West Virginia. The mountains there con-

tain mines of sand said to be as pure as that from Fontainebleau.

Sandstone

Pure sand may be obtained by crushing sandstone, but the grains thus obtained are not likely to be so uniform in size as those from a sand bed, and the necessary grinding makes its preparation more expensive and tedious.

Quartz

Quartz is crystallized sand. It appears in nature as rock crystal, a transparent and colorless variety, and also in a number of semiprecious stones, such as the amethyst and false topaz. These forms of silica might be crushed and used for glass, but their hardness and intrinsic value make them too expensive for such use. Low-grade quartz is sometimes used.

Flint

Flint is a form of quartz containing lead and potash, which appears in certain localities in the form of boulders or large pebbles. It was used very generally by the early English glassmakers. The name "flint" is still applied to a kind of glass that is soft, brilliant, and suitable for cutting. Now, however, this kind of glass is usually made from oxide of lead and is more com-

monly referred to as crystal or lead glass. In France these flint pebbles are still gathered on the sea and river shores and carried by the peasants to the glass-makers.

Flint must be finely ground before being used, and as this is an expensive and tedious process, it is suitable only for the best grade of glassware.

The various trade terms in use are apt to be somewhat confusing.

"Lead flint" glass contains:

Sand or silica
Oxide of lead
Potash or pearlash (a special form of potash)
Saltpeter

"Lime flint" glass contains:

Sand
Lime
Bicarbonate of soda
Saltpeter

"Strass" is a flint glass with a large amount of lead; it is used for making artificial gems.

Kelp or Seaweed

Seaweed and other forms of plant life were at one time another source of silica, as the stalks of many sea plants, such as kelp, are stiffened with it. Modern

invention, however, makes it more profitable to utilize such sea plants by extracting the potash and soda they contain rather than the silica, which may be obtained by less expensive methods.

Alkalies

Next in importance to sand or silica among the constituents of glass are the alkalies, potash and soda. They are necessary in order to make the other materials melt and combine and are called "fluxes." Modern glassmakers obtain them from natural deposits and prepare them in special factories. Both are found in nature in various combinations: chlorids, sulphates, carbonates, and nitrates. The forms generally used, carbonates and sulphates, are the most desirable from the glassmaker's point of view, since they are the purest and of the most uniform composition.

Potash

Pearlash (potassium carbonate) is the form of potash most commonly used. Crude pearlash is obtained from ashes as a by-product of the beet-sugar industry and is used for inexpensive glass. Saltpeter (potassium nitrate) is another form valuable for its oxygen and alkali. Ancient glass contained potash made from seaweed or kelp, but this was inferior to modern potash because of its impurities.

Natural deposits of potash were discovered in the mines of Strassfurth near the River Elbe in Germany, and almost the entire world became dependent on them. When war conditions shut off the supply, the potash situation became serious. Fortunately for the American industry, local fields of kelp were discovered, which brought relief for the time, but Germany is still the great source of the world's supply.

American Potash

A potash mine is being worked in New England, where a shaft 1,000 feet deep has been sunk. Night and day shifts are working the deposits. It has been known for a long time that there are considerable potash deposits in the vicinity, but they were not mined to any extent until the cutting off of the European supply made the mining of potash in this country worth while.

Large amounts of the compounds of this element are present in the vast beds of kelp floating on the waves of the Pacific near the western coast. Each year the waters of the Pacific coast yield a crop from which potash salts possessing a normal value of more than $90,000,000 can be readily extracted for use in agriculture and the arts. Not only are there inexhaustible supplies in the waters of the Pacific, but also remarkable deposits in the arid waste about Searles

Lake in California, and in Utah. Beds of kelp have also been discovered in the Philippines.

Soda

The general use of soda as a flux is a more recent development than the use of potash, though much of the glass of ancient times was soda glass. As with potash, it was first obtained from the burning of seaweed.

Soda-Ash

Soda-ash (sodium carbonate) is the purest form and is used in the better glass works. It is made by treating the natural soda deposits with certain chemicals.

Salt-Cake

Salt-cake (sodium sulphate) is a cruder form used in making bottles and the heavier glassware. It is produced in the same manner as soda-ash.

Chile Saltpeter

Chile saltpeter (sodium nitrate) is used in the crude state or refined for the better ware. The nitrates of both soda and potash are valuable for the alkalies they contain, but more particularly for the oxygen which aids in freeing the batch from bubbles.

Lead and Lime

The third necessary ingredient of glass is either lead or lime. Lead is used for the best cut glass, because of the brilliancy, resonance, and weight which it gives. It also lowers the melting point of the batch.

Forms of Lead Used

Lead oxide is an expensive material for glass-making. Red lead, the form generally used, is of a bright red color. It is preferable to other oxides because it is easily decomposed by heat. It is made by roasting metallic lead in furnaces to eliminate the impurities present, such as silver, iron, and silica. Red lead is very poisonous and the workmen in flint glass factories have to wear respirators to keep them from inhaling lead dust while they are preparing it. In good factories perfect cleanliness is also insisted upon so that the lead may not poison the workmen's food.

Kinds of Lime Used

Lime (calcium oxide) is a much less costly material. It makes a harder glass than lead, and for this reason lime glass is not suitable for cutting. It may be used, however, for all kinds of pressed ware and for many varieties of art glass where lightness and delicacy are desired. Lime adds to the viscosity of

the molten glass, and so increases the toughness and serviceability of the finished product. If used in excess, it gives the glass a milk-white color.

Lime is found in many parts of the world, appearing as:

Limestone rock
Chalk (calcium carbonate)

Chalk is a soft, brittle rock which can be easily ground into a fine powder. It is often mixed with iron, flint, and magnesia, which impair its quality.

Gypsum (calcium sulphate) is a form of lime less pure than limestone, sometimes used in glass-making.

Other Materials Used

Other materials added for special purposes are:

Aluminum
Arsenic
Barium
Borax
Magnesia
Zinc

Aluminum is found in small quantities in nearly all glass, but a larger percentage is used in opal or optical glass.

Arsenic acts as a flux and neutralizes certain objectionable colors.

Barium replaces lead for some purposes of glass-making. It is an expensive material.

Borax adds to the density and brilliancy of glass.

Magnesia is similar to lime, for which it is sometimes substituted.

Zinc contributes some of the same qualities that soda and potash do. It is used in special optical glass.

Coloring Materials

Transparent colored glasses are made by simply adding coloring components in relatively small quantities, to the clear glass batch. These are usually metallic oxides: copper or cobalt for blues; chrome or iron for greens; silver or uranium for yellows; and gold chlorid or seleniun for ruby. The deep amber used for bottles is made by adding carbon with sulphur in some form; this is generally coal dust, but any of the grains wheat, oats, barley, or even sawdust, will make a rich amber color.

The opaque and semiopaque glasses require the same foundation mixture, but other materials in larger proportions are needed to insure sufficient opacity. Some of these other materials do not become chemically components of the glass, but remain in mechanical suspension only, i.e., floating in fine particles, and tend to destroy the uniformity and strength of the glass.

Others exert a destructive action on the pots or crucibles holding the batch.

These are some of the reasons why opaque glass has not been in more general use for the manufacture of hollow wares, but recent progress has been made in eliminating or neutralizing the injurious effects of the ingredients referred to, and producing a material which will stand rough usage. Opaque glass is therefore now invading a field which hitherto has belonged exclusively to the potter.

The translucent lighting glass now so much in favor, because of its superiority, is crystal glass to to which has been added opacifying components, the most essential being oxide of aluminum.

Lead and bismuth are the only metallic oxides which can be added to silica and alkali without discoloring the batch. Even an excess of lead gives a yellowish tinge.

Owing to the presence of metallic substances in nearly all sand used for glass-making, colored glass has always been more common than that which is clear and colorless.

Color which is muddy and dull, such as the green or the brown tinge of common bottle-glass, is due to the use of low-grade materials; but the colors which may be produced by the introduction of carefully prepared metallic oxides, which are used with a scientific knowl-

edge of their effect on the silica and alkali of the batch, add the final touch of beauty to decorative glass which brings it into the region of the fine arts. The further discussion of color therefore belongs in the section devoted to art glass.

Chapter III

MANUFACTURE OF GLASS

Careful Preparation of Materials

The quality and the appearance of finished glassware depend upon the purity and fineness of the materials of which it is made, and the proper proportions of each in the mixture which forms the batch. Each material must also be as free as possible from water, as moisture hinders the melting process.

Preparation of the Sand

Sand for the manufacture of glass is first carefully examined under the microscope and analyzed by chemical tests for purity. It is then emptied into receptacles containing a large quantity of clean, pure water, moved about vigorously, and allowed to settle. As it is heavier than water it naturally falls to the bottom, while the particles of foreign matter which float upon the top are drawn off with the water.

The sand is next burned to remove the moisture and to destroy any vegetable matter which has not been taken out. For this process it is placed on the bed

of a moving oven which travels continuously through flames.

From the oven bed it is dropped into a vault through a series of sieves covered with fine copper gauze. This sifting process not only removes impurities but also aids in procuring a sand with grains of uniform size.

The other materials are usually refined and prepared before they reach the glass manufacturer.

Mixing the Batch

The mixing of glass materials must be done with scientific accuracy, as an excess or deficiency of any one of them affects the appearance and quality of the finished product. Too much sand keeps the batch from melting, and too little potash or soda has the same result. Too much lime or lead affects the color and quality. All coloring compounds must be used with a knowledge of their chemical reactions in order to produce the proper effect.

Each formula must therefore be prepared by a trained chemist, and every ingredient carefully weighed. The formulas for certain kinds of glass are secret, and even the workmen are kept in ignorance of them lest they should disclose the processes to a competing manufacturer. For small batches the weighing and mixing are done by hand, but for larger

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quantities by machinery. In the weighing process only the ends of the scale beam may be seen by the workmen, the exact proportions being known only to a few members of the concern.

After weighing, the materials are all collected in an "assembly box" and dumped into a hopper, which empties its contents into the mixing machine. This machine rotates in various directions while revolving steel arms within the mixing chamber stir the contents. Samples of the batch are taken out and examined. When the sample shows that the whole mass is uniform in color and texture, the "cullet" or "frit" is added. This is a special mixture of materials in a pulverized and half-molten state which hastens the process of melting and fusion for which the batch is now ready.

Fusing and Fining

The fusing of the materials into a uniform molten liquid out of which glass articles may be formed is a most interesting process.

After the fusing the next step in the manufacture is fining. By means of intense heat and some material containing oxygen, impurities and gas bubbles are removed. Both of these important processes are described in greater detail in the latter part of the chapter. Both take place in glass furnaces.

Glass Furnaces

Three kinds of furnaces are needed in a glass factory:

1. The working furnace, either:
   (a) Pot or crucible furnaces, or
   (b) Tank furnaces
2. The calcar furnace for making frits
3. The annealing oven

The first two kinds are described in this chapter, the third in Chapter IV.

Careful Construction of Furnaces

Furnaces for making glass must be built with a view to durability, regularity, and intensity of heat, and also economy of fuel. Since they must resist a temperature of between 1,800° and 2,700° F., glass furnaces are constructed of fire-proof bricks made of an infusible clay mixed with cement obtained from the pulverization of old pots — the containers for molten glass. The fire of the furnace never goes out until the furnace wears out after one or two years of service.

Glass furnaces have much in common with pottery furnaces except that the heat of the glass furnace is more constant. Upon the regularity of its heat depends the safety of the crucibles as well as the quality

of the glass they contain. Sudden variations of temperature tend to crack the crucibles and irregular cooling " striates " or streaks the glass.

The furnace must be constructed so as to resist great heat and avoid drafts, and must be very durable. The fuel must be as free as possible from impurities, and the degree of heat applied and the duration of the fusing process must be carefully regulated or the entire batch may be wasted.

Fuels

The kind and the quality of the fuel used in a glass furnace is of importance. Wood was naturally the first fuel to be used. It made a clean heat but one of slow and uncertain temperature, varying with the kind of wood used and with its wet or dry condition. The old glassmaker, like the old potter, knew the value of the various kinds of woods for his purpose and chose them accordingly.

The use of coal necessitates covering the pots in which the glass is melted to prevent the soot and sulphur from coming in contact with the glass and thus filling it with small particles of harmful matter as well as affecting its color. This was a constant annoyance to the glassmaker.

The introduction of the hooded pot necessitated the addition of more fluxing material or of more heat to

make the batch melt, because the hood prevented the flame from touching the batch as in the case of open pots. The discovery of gas as a fuel solved the problem for this country.

The glassmaker of modern times owes much to the discovery of natural gas as a fuel. It makes a smokeless flame and has scarcely any impurities. It provides a uniform heat and there is no discoloration from smoke. It gives no trouble through the accumulation of ashes or dirt.

The introduction of gas as a fuel has revolutionized the whole glass-making industry. In the United States both gas and petroleum are used. Even for pot furnaces gas is used; in tank furnaces it is indispensable. Natural gas is employed wherever it is obtainable. Where there is no natural gas, artificial gas is made from other fuels.

Pot Furnaces

The pot furnace is circular, with a chimney in the middle through which the smoke, flame, and heated air escape. At the base of this enormous chimney is a central fire, and fire bars occupy the middle of the furnace floor. On the sides of the furnace are recesses in which the workmen stand; and on the inner sides of these recesses are openings into the pots or crucibles

which are placed opposite on a clay stand or shelf around the circumference of the furnace.

Each crucible has one small opening only, near the top, in the shape of a neck projecting out through the furnace wall. Through this opening the batch is poured into the crucible; during the melting it is tightly sealed so as to be practically air-tight, and no direct flame, smoke, or heat gets to the fusing glass. Because of

Figure 1. Open Pot for Glass-Melting

Figure 2. Covered Pot for Glass-Melting

this protection from outside influences it is possible to make glass of greater luster and better color than can be made otherwise in the present state of the art. The word "color" is here used in its technical sense as applied to crystal glass. When a glassmaker says his glass is of good color, he really means that it is without color, or as nearly so as he can get it.

A furnace is described as having so many "pots," the number of these indicating its size. The pots vary in shape and capacity. They may be round, oval, or rectangular, from 18 inches to 3 feet in height, and

with open, or "hooded" or domed tops. They may hold a few pounds (monkeys), or several tons of molten glass. Figure 1 shows an open pot; Figure 2 a covered one.

Pots last only a few weeks though it takes months to make them. While in use they require the most careful attention, as the intense heat widens even the smallest crack and soon breaks the pot. This means the loss of the entire batch of glass.

The process of making glass in a pot furnace may be more carefully regulated than is the case with other processes, because the glass is in comparatively small quantities and the molten mass may be kept from contamination by the gases and other impurities always present, especially when the fuel is other than natural gas. The pot furnace was the one used by the old Venetian glassmakers in making their beautiful and fragile glass. Pot furnaces of an improved type are largely used today in making cut or pressed glass, and especially in making optical and colored glass where quality is of the first importance.

Fire Clay

The pots must be made of a special grade of fire clay. An extraordinary amount of care is required in the manufacture.

Fire clays are clays which contain a large amount

of silica and a small percentage of fluxes or binding materials, so that they can withstand a high temperature. Fire clay is found in nearly every part of the United States, especially in New Jersey, Pennsylvania, Ohio, and Missouri. The pot clay found near St. Louis is said to be unsurpassed even by the most celebrated clays of Europe.

Manufacture of Pots

When the clay has been finely sifted it is well mixed with burnt clay or unglazed fragments of broken pots, which tend to bind it together. Skill is required in mixing and working the ingredients in order to drive out every particle of air which, by expansion in the furnace, would break the pots.

After the mixed material has been made into the creamy substance known as "slip," as if for pottery, it is given a definite shape by casting, molding, or building. The practice is to make several pots at a time so that one may partially set while another is being built. The pots are allowed to stand for from 8 to 12 months in a temperature of from 90° to 100° F. They are then placed on fire clay blocks in a baking furnace and subjected to a red heat (1,800° to 2,700° F.) for several weeks. If they do not crack or melt at this temperature, they are fit for use.

In addition to the prolonged heat of the glass furnace, the pots must be able to withstand the corroding effects of some of the raw materials in the batch, such as red lead, potash, soda, and borax. This corroding may even go so far as to make a "specky" glass, which is formed by a combination of the aluminum, usually found in the pot clay, and the alkaline or metallic ingredients of the batch. To prevent this, the crucible is glazed on the inside.

Tank Furnaces

The tank furnace is a square or rectangular oven with doors at the ends. It varies in depth from 20 to 42 inches according to its purpose.

One end is called the "filling hole" and into this the batch is shoveled. The other end is called the "working hole" and from it the molten glass is taken to be molded. This arrangement permits continuous working. The portions of the tank which come in contact with the molten material must be made of the special grade of fire clay which is used for the pots in the pot furnaces. The tank furnace is in reality a single open crucible. In practice it is often of large dimensions and is never closed nor covered.

A horseshoe flame (shown in Figure 3) is used in a tank furnace and is so regulated that each part of the furnace remains at the same temperature during the

whole time that the furnace is working. The flames of the fuel play over the melting batch so that the fusing is much more rapid and efficient, with a resulting economy of fuel. Unfortunately, exposure to the atmosphere and the direct contact of the glass with

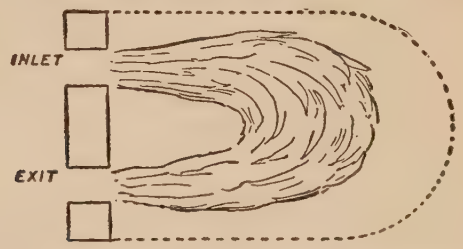

Figure 3. Diagram of a Furnace with a Horseshoe Flame

hot gases in various stages of combustion, make the regulation a much more difficult and uncertain matter than in the closed pots.

For making glass of the finest quality, such as that for cutting and the best grades of pressed or blown wares the pot furnace is best suited.

The tank furnace, on the other hand, has the advantage of producing glass of greater uniformity, free from cords and streaks, and is therefore well adapted for making blown ware such as bottles of all sorts, lamp chimneys, glass lamps, thin blown tumblers, etc. — in fact any or all articles in which clearness is of more value than the color tint. Progress is being

made in the building and manipulating of tanks, and it is not unlikely that in the near future this type of furnace will produce glass which will in all respects equal that made in pots. Glass which is in no respect inferior to pot glass is even now being made in tank furnaces. This, however, is not through any change in furnace construction, but through increased knowledge as to the use of decolorizing materials which, when added to the glass batch, neutralize objectionable tints.

The C tank is a modern type of furnace invented in 1861 and used largely throughout Europe and America. It is made from pot clay and divided into "floating compartments," each at a lower level than the one immediately before. The raw material is put in at the door, and as it melts, flows from the first compartment into the second, which is the refining compartment. Here the temperature is higher and the refining takes place. From this compartment the refined liquid passes into the gathering compartment, where at a lower temperature it cools and thickens for the forming. These furnaces may be worked continuously and are in many ways better than the old style of tank furnace.

Calcar Furnace

The calcar furnace is in the form of an oven about

10 feet long, 7 feet wide, and 2 feet high, in which some of the batch materials are partially melted, forming a pasty mass out of which the moisture and gases have been driven. This mass is allowed to solidify, and while yet soft is cut into squares, which are stored for use as frit or cullet. (See page 22.) When these frits are mixed with the batch they hasten the process of fusion.

Fusing Process

In the case of a tank furnace the batch is put in through openings in the melting end by means of long-handled shovels or some mechanical device, and new material is added every half-hour for four or more hours.

When pot furnaces are to be filled, the pots must first be entirely emptied and the temperature of the furnace brought up to 2,500° F. before the new material is put in, since a low or an unequal temperature has a disastrous effect on the batch.

As in the case of any boiling liquid, allowance must be made in each pot for the bubbling up of the boiling mass so that the pots may not overflow and cause the loss of valuable material. As they boil down, fresh material is added; four to eight fillings are customary.

Fining Process

The batch has now become a mass of foaming, seething, molten glass. Gradually it changes to a viscous and entirely transparent substance full of gas bubbles. As any bubbles in the finished glass are an obvious defect, however, their removal has been provided for by putting into the batch some materials containing oxygen. The heat of the furnace is increased until this oxygen is freed and forms large bubbles, which rise to the surface and carry the smaller ones with them. This is called the fining process. The more liquid the mass is, the more readily will the gas bubbles disengage themselves. For this purpose "fluxes"—substances which promote the chemical action just described — are added. The glassmaker sometimes uses arsenic or a substance containing moisture, such as a potato attached to a rod.

When the fining process is completed, the melter takes out samples or proofs of the liquid on a rod or a long spoon and examines them for bubbles. If impurities have gathered the surface is also skimmed.

The melting and fining process takes about 24 hours. Then the temperature of the furnace is lowered to working heat and the shaping and working of the glass is begun.

Chapter IV

FINISHING PROCESSES

Removing Molten Glass from the Furnace

Molten glass, as has been said before, is not liquid but viscous; as it cools it passes to the solid form without crystallization and while cooling can be shaped according to the glassmaker's will. While in this semiliquid condition glass has the malleability and ductility which metal has, that is, it may be hammered or rolled without cracking, and it may be drawn out into a wire. The glassmaker speaks of the molten glass as "metal."

There are three methods of removing it from the pot or tank:

Gathering
Ladling
Pouring

Gathering is the process of removing a part of the mass by twisting it around the end of a long tube. It is the method employed in making all blown glass and much of the molded and pressed ware. Gathering re-

quires great skill, and makes an admirable display of dexterity. Like the art of juggling, it can be learned properly only in early youth.

Ladling is the process of transferring the molten glass to large tables by means of long ladles.

Pouring is done by machinery which lifts and tips the heavy pots so that the glass flows out.

Methods of Shaping Gathered Glass

The glass obtained from the pot by gathering is shaped or formed by:

Blowing
Pressing
Molding

Glass-Blowing

Blowing is the most primitive and characteristic way of forming glass. Formerly all glass, even that for window panes, was shaped entirely by this process. It is the method still used to form the blanks for the best cut glass and for all pieces of delicate design.

The glassblower's tools are:

Blowing iron or blowpipe
Working rod
" Battledore "
Glass blowpipe

Shears
Pincers
Tongs and similar pronged wooden tools
Measuring stick and compass
Spring balance

The most important tools in the process of blowing are the blowpipe and working rod.

The blowing iron or blowpipe is a long hollow iron rod varying in length from 5 to 6 feet and in diameter from ¾ to 2 inches, according to the weight of glass to be gathered.

The working rod is a light, tapering rod of solid iron varying much in both length and strength. It is used to hold the vessel in the last stages of manipulation.

The "battledore" is used to flatten the square bottoms of tumblers or other vessels; the glass blowpipe in expanding the opened end of bulbs; the shears in removing surplus glass, or cutting the ends of handles or rods; the pincers in shaping the handles of jugs or the decorative filigree work on vases; tongs and similar pronged wooden instruments in handling and opening up certain pieces; the measuring stick and the compass for marking with wax the amount of surplus glass to be removed with the shears; the spring balance in comparing the weight of each vessel with that of its patterns.

Courtesy of United States Glass Co.

Figure 4. Rolling Glass on Marver

STEELE HIGH SCHOOL LIBRARY

A "marver," or table upon which the glass may be rolled about while it is being shaped, completes the equipment.

How a Glassblower Works

The blower gathers a mass of the viscous glass from the pot on the end of his iron blowing pipe, adding

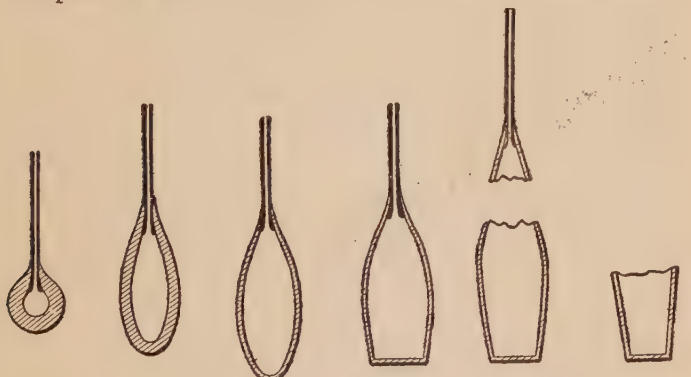

Figure 5. The Evolution of a Tumbler

more and more as it cools until he has the amount necessary for the article he wishes to make.

By rolling or marvering the ball over the polished surface of the table just referred to, he makes it uniform in shape and free from bubbles. Figure 4 shows this operation.

He then inflates the mass by blowing air into it through the tube, also exposing it from time to time

to the heat of the furnace, which further expands the air until the article is enlarged as much as he wishes.

Figure 5 shows the various stages in the making of a tumbler. The flat bottom is shaped by pressing the lower end of the elongated bulb of glass on the marver.

The process of glass-blowing is fascinating to watch. The shapeless mass is twirled, pulled, and thrown about with perfect control and ease until it assumes its final, beautiful shape. We are accustomed to think of glass as so fragile that it can be handled only with great care and this makes the glassblower's work seem almost magical.

The blowing of glass by the breath may have been originally suggested by the bubbles which appear in the molten glass. It was evidently practiced in Egypt, for Egyptian monuments as early as 2000 B. C. show glassblowers working with their pipes.

The blowing was done entirely by the breath until 1824 when M. Robinet of the Baccarat factory invented the Robinet pump, by the aid of which large cylinders could be made. This gave rise to the compressed air and automatic blowing machines which do much of the work today.

Pressing Glass

The metal for pressed glass is gathered on a solid iron rod from 4 to 6 feet long, called a "punty." The

punty is thicker at one end to allow a good hand-grip, and forged at the other end into the shape of a knob. The worker heats this knob, dips it into the molten glass, and by twisting it covers it with a layer of glass, which he manipulates into the shape of a ball, and cools until it is nearly solid. The ball of glass is called the "moil," and is made larger or smaller according to the amount of glass to be gathered.

The gatherer now inserts the punty into the pot mouth, dips the moil into the liquid glass, and begins a rotary movement, slowly at first, then with greatly accelerated speed literally gathering up the glass, until he has the needed amount suspended in a droplike fashion beyond the end of the punty. He then carries, or rather juggles, the ball of liquid glass to the conveniently placed press, and drops it deftly into the mold. Another worker, the presser, severs the connecting thread between the body of glass and the punty with a pair of scissors.

Molds for pressed ware are usually made of cast iron, and are simply matrices of the size and shape of the article to be made, marked with any pattern which is desired for the outside of the article. A plunger, forced into the mold by a lever operated by hand or machine, shapes the inside of the article. The molds must be constructed to admit of a ready removal of the pressed article. They are, therefore, either of

one solid piece of iron, from which the article can be dropped out by turning it over; or they are made of a number of sections jointed and hinged together. The latter sort are used for shaping the more complex forms of glassware or those ornamented with deep designs, as, for instance, an imitation of cut glass.

The temperature of mold and plunger is carefully regulated by streams of air blown against them; otherwise the surface of the glass might be cracked or roughened.

When the glass has hardened the plunger is removed and the shaped article is taken from the mold. It must be smoothed on the inside to remove the roughness made by the plunger and if marks of the mold are left, plain pieces are reheated in the "glory hole," as the side openings into the furnace are called.

Pressed Glass Used in Imitations

Pressed glass is made to imitate cut glass and the old hand-carved art glass of Venice or Bohemia.

There are three ways of telling an imitation:

1. The angles of the design in the imitation are blunt and rounded instead of being clean cut and sharp.
2. The design is very symmetrical and usually commonplace.

3. The glass lacks the brilliancy given by the processes of hand-cutting and hand-polishing.

Molding is a combination of the blowing and pressing processes.

Molding

A mass of molten glass is gathered from the crucible on the end of the blowpipe. After being marvered and slightly expanded it is thrust into the mold, which shapes the outside while continued blowing forms the inside. Molded glass differs from pressed glass in the fineness of its finish, as it is partly a hand-process.

Molds are of many shapes and may be of complex construction. They may be of two, three, or more separate pieces hinged together so that the molded article may be easily removed.

They are made of cast iron or other metals, plaster of Paris, clay, or wood. The metal molds are strongest, but the metal is apt to discolor the glass. This difficulty is met by lining the molds with wood or carbon. Cork-lined molds are sometimes used to give blown ware a uniform shape and size.

Figure 13 in Chapter XVIII shows four old Roman molded glass pieces.

Annealing

After the glass articles have been formed and cooled, it is necessary to subject them to a process known as annealing.

Annealing is the reheating and cooling of the formed glass, and is one of the most important operations in glass-making, since it is this process which makes it resistent to blows and changes of temperature. Glassware which is not properly annealed is very fragile and easily broken. Annealing also adds to the brilliancy of the glass.

Process of Annealing

The glass articles are placed in annealing kilns or ovens (often known as "lehrs"), and heated to a temperature of 800° F. The heat is gradually raised to 1,200° F. and then gradually lowered, so that the articles cool slowly. It is this gradual cooling which makes the glass strong, durable, and of uniform and consistent texture, since the pores, expanded by the heat, are allowed to contract evenly throughout the entire substance. When cooled quickly the surface shrinks more rapidly than the inside and therefore is under a greater strain.

Large heavy pieces require a longer time and greater heat than small thin pieces. The time may vary from a few hours to a week.

Varieties of Kilns

Ordinary kilns or ovens are used for heavier articles, such as blanks for cutting and plate glass, which must remain in the kiln for a considerable length of time.

The continuous lehr or kiln is used for lighter articles. This style of annealing oven has a long rectangular chamber or tunnel of brick heated at one end and provided with numerous small iron trays or trucks, which are moved by an endless chain. The pieces of glass are placed on the trays at the hot end and gradually moved towards the cooler part of the oven, making room for fresh pieces.

The labor required for piling up and taking down the glass in a kiln is saved by using this continuous oven.

The famous Murano glass works (see Chapter XVIII) had a simple arrangement for annealing, consisting of a tunnel about thirty feet long, which was heated by the waste heat from the melting furnace. It had a tramway running down the center with movable trucks, on which the glass was drawn from one end to the other.

The intermittent kiln or oven is heated by gas and fitted with a shelf on which the glass is set. When filled with ware it is closed, heated, and allowed to cool; the process is controlled by carefully regulated drafts.

A novel method of annealing was invented by a Frenchman named De la Bastie. The pieces were put in a wire frame while yet soft and immersed in a hot liquid, preferably mutton fat. For various reasons the process was not very successful and did not displace the annealing oven.

Polishing

Much of the beauty of glass is due to its brilliancy and the reflection of light from its polished surface. A natural polish is produced by the processes of fusing and annealing, but in cut glass this is destroyed by the action of the water and sand on the cutting wheels. Polishing is an important feature of the glass-cutting process.

Pressed glass is dulled by coming in contact with the sides of the metal molds, which chill the surface too quickly. This luster may be restored by placing the piece in the "glory hole," where it is held in an intense flame, which gives it what is known as fire polish.

Old glassmakers reheated their glass many times, since each period of heating and cooling added to its brilliancy.

Today the acid polish, described in Chapter VI, is given to the better grades of pressed glass and to all but the finest cut glass.

Defects in Glass

If the materials of which glass is made are impure or improperly combined, the color will be poor; for instance, an excess of iron will give a greenish or a brown tinge. Too much manganese gives a pink tinge.

" Bottle glass," which is used for the cheaper grades of bottles, is colored by the iron and other impurities which it contains.

Glassmakers have trade terms for defective glass, such as:

" Seedy " glass, which contains small air bubbles caused by too rapid melting or too low temperature in the furnace.

" Stony " glass, which contains tiny lumps of undissolved material or clay from the sides of pots or tanks.

" Cordy " or wavy glass, with waves or streaks of crystallized glass instead of a clear, even texture.

" High color " is the pink tinge from manganese.

" Low color " is the green tinge from iron.

Glass may be imperfectly formed or it may be poorly finished.

Cut glass should not be cut too deeply and the edges,

while clear and sharp to the eye, should not be knife-edged or rough to handle.

Differences in Glass

Lead glass is heavier and more brilliant than lime glass, but the difference is not always apparent to the untrained buyer or salesperson.

Pressed glass has a dull finish as the result of the chilling given the hot molten glass, or "metal," as it is called, by the mold. This may be removed by re-heating, and the "fire polish" is restored to all good pressed glass.

Colored or decorated glass is subject to many accidents in fusing or firing the color.

Defective articles are usually discarded by the manufacturer to be sold as seconds, or, if too imperfect, to be remelted and formed again.

Chapter V

BOTTLES AND OTHER SPECIAL FORMS OF GLASS

Bottle-Making

Bottles were among the earliest forms of glass vessels, and bottle-making is still a special division of the industry.

They are:

1. Blown and shaped by hand.
2. Molded.
3. Blown and pressed by automatic machines.

Bottles made entirely by hand are now found only in art glass or among articles of luxury. Even finely cut bottles are usually molded.

Blown Bottles

For blown bottles the process is as described in Chapter IV. The molten glass is gathered on the blow pipe, rolled or marvered on the flat metal plate, and blown with the breath until it is nearly the required size. During the process the pipe is swung gently to

and fro, so that the glass settles downward, leaving a thinner part next the pipe to form the neck. It is then reheated and is either blown into a mold of fire clay or metal, or shaped by hand tools. If there is to be a concave bottom, as in wine bottles, this is made by pushing up the hot glass by means of an iron rod called a pontil, upon which a small mass of glass has been gathered.

The bottle is now attached to both the pontil and the pipe, but by chilling the glass the pipe is broken off at the point where the neck is to end. The neck is heated to make it smooth, and a thread of glass is wound round it to give the proper stiffness and finish.

By various inventions machinery has been substituted for each of these processes in bottle-making.

Molded Bottles

The first change consisted in operating the mold by a lever, one-half of the mold being attached to the floor and the other raised by the workman by means of a rod. This mold gave the bottle its final shape.

By another machine the glass is gathered on an iron rod and dropped into a measuring mold, which assures the right quantity. This material is then forced into a neck mold, which gives the shape of the neck of a bottle. While the neck mold is still firmly attached a plunger is forced down through the material and then by means of compressed air the lower part of the

bottle is blown out to the proper length and fitted into a third mold, called the finishing mold. Levers open the finishing and neck molds at the same time and release the perfect bottle. This machine is capable of producing 120 bottles per hour.

The Owens Automatic Bottle Machine

The automatic machine takes the place of human hands and requires no skilled workmen at all. A furnace is built with revolving pots, in front of which the machine is placed. As the pots revolve, the machine, driven by an electric motor, moves with them. It has either six or ten arms carrying "blanks" and finishing molds. As each blank mold passes over the pot the molten glass is sucked up into it by a vacuum process, which is regulated to supply just the right quantity for the bottle required. The neck is formed while the glass is in this first mold.

Then the blank mold opens and the glass is shown as a white-hot cylinder supported by the neck; the finishing mold rises and closes over it and the shape is finished by the application of compressed air. After making a complete turn the machine drops out the finished bottle, which is put into the tempering ovens and travels slowly towards the cool end, where it is ready to be packed and shipped.

The regularity of the mechanical process and the

even pressure of the air produce bottles of a uniform strength and quality.

Glass for Insulation

As glass is a non-conductor of electricity and a very poor conductor of heat it is the best material for insulation. Telephone and telegraph wires are wound on glass caps to prevent the loss or transference of the electricity. The recent shortage of timber in Europe has occasioned the use of telegraph poles which have a frame work of woven wire in the center but are otherwise made entirely of glass. These poles will neither rot, rust, nor be destroyed by insects and are therefore worth a greater original cost.

Spun glass is used as insulating material in electrical ovens, which will retain their heat for a long time after the current has been cut off.

Bullet-Proof and Safety Glass

One of the greatest objections to the commercial use of glass is its brittleness, which not only causes it to break easily but to splinter and fly under mechanical shock and cause very serious accidents.

Bullet-proof glass was invented for war use and various forms of safety glass are made in a way that prevents this splintering. The glass is made in two thin sheets with a layer of transparent, shock-resisting

material between, and the three layers are fused into a solid sheet. The adhesion is so perfect that it looks like ordinary glass but when struck with great force it will only crack. The splinters are held by the binding material and cannot fly off. Safety glass is chiefly used for wind-shields, headlights, and lenses for automobiles and for goggles. During the war gas-mask lenses, aviators' goggles, and aeroplane wind-shields were made of it.

Wire glass is an older material made on the same principle. A wire mesh is inserted between two layers of rolled plate for use in the windows of factories, gymnasiums, etc., where it is subject to jarring or striking, and also as a protection against fire. The metal, however, affects the transparency of the glass as well as being itself quite visible, while the binding material in safety glass is not.

Colored Glass

Mosaics are composed of glass with the addition of various mineral compounds. The glass is melted and mixed with colored powders until it becomes a thick mass. Then the mass is slowly baked until it has reached the required degree of hardness, when it is taken out and molded into small cubes, or "palettes."

In making a mosaic picture the artist sketches the design with charcoal on a slab of plaster. Small holes

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are hollowed out with a piercer and the mosaic cubes are chipped to fit in the holes where they are held by means of a glue or cement.

In the city of Lyons glass pavements have been recently laid. They are composed of "ceramo crystal," a devitrified glass in blocks 8 inches square. This is a return to the mosaic glass pavements used by the Romans.

Colored glass is used for many other purposes, useful and decorative. Among the former is the use of ruby, green, and purple glass for signaling purposes in railways, motor cars, and lighthouses. Photography also makes extensive use of colored light for various purposes, and medical science and beauty doctors require colored light.

Part II—Cut Glass and Tableware

Chapter VI

CUT GLASS

Characteristics

There are three grades of glass which are known as cut glass. The best grade is cut entirely by hand; the second grade is first pressed and then finished by hand; the third is merely pressed in patterns which imitate cut glass.

Genuine cut glass has four characteristics known to the expert. These are:

1. Its color — a clear, brilliant white tinged with steely blue
2. Its bell-like resonance when struck
3. Its weight
4. Its fine finish

These characteristics depend upon the materials of which it is made and also upon the process of manufacture. A well-known manufacturer recently gave the following definition: "Cut glass is and always

has been a piece of crystal cut on wheels. The design is cut in, not pressed in, nor blown in; and it is polished by hand. Genuine cut glass is not then partly retouched, pressed lime glass."

An authority on testing cut glass says: "First note that the article is really cut. This can be detected by the sharp edges of the design as well as by the delicacy and intricacy of the design itself. Second, tap with a pencil. If the glass contains lead, a necessary ingredient of all good cut glass, it will resound like the ring of a deep-toned, silvery bell."

Materials

The materials from which genuine cut glass or cut crystal is made are:

Silica or pure sand
Oxide of lead
Potash

About 60 pounds of lead are used for each 100 pounds of silica; the lead gives weight, resonance, and brilliancy and also keeps the glass soft for cutting. The potash is used to clarify the glass and to add to the scintillating effect. All the materials must be pure.

Process

The earlier stages of the process are the same as for

blown glass, that is, making the blank, the rough shape resembling the general outlines of the piece to be copied, includes:

Gathering the material
Blowing into shape
Annealing

There are certain differences. The roughly shaped "blank" is heated three times and worked over by three different workmen. In the annealing oven the glass is brought to a particularly high temperature and is cooled very gradually.

The blanks for cut glass are blown much thicker than for articles which are not to be cut, particularly if the piece is large and the incision must be deep. Some pieces lose over one-third of their original weight during the cutting process.

Designing and Cutting

The second part of the process is quite different. It includes:

Tracing the outline of the design
Roughing
Smoothing
Cutting fine lines
Polishing

The shaped blanks are stored on the shelves of the

factory in which the cutting is to be done. Each large glass-cutting establishment employs its own artists, who design both the shapes and the decorations of its pieces. The designs must be mathematically accurate and suited to the spaces they are to occupy.

Tracing the Design

First the design is outlined with a brush in red lead and turpentine, or transferred from a stencil or a copperplate pattern.

Cutting Wheels

Glass is cut on wheels made both of steel and of stone. These wheels may vary in diameter from 1½ inches to 3 feet, and in thickness from ¾ of an inch to 1 inch. They are driven by steam, gas, or electrical power. The larger wheels are used for cutting straight lines and the smaller ones for curved lines. The sharper the curve, the smaller must be the wheel. The face of the wheel may be round, square, or pointed. As many as fifteen or twenty different kinds of wheels of different degrees of hardness are used in the cutting process. Figure 6 shows the cutting room in a glass factory.

An expensive and novel form of cut glass is made by stone engraving, a form of cutting done entirely by hand with stone wheels and copper tools. The de-

Figure 6. Cutting Glass

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signs are chiefly vines and flowers and are not cut deep. This is sometimes mistaken for pressed glass.

Expert Knowledge Required

Glass cutters must be expert workmen, as their material is heavy and yet easily broken and mistakes can seldom be corrected. The operator holds the blank against the wheel with just the right amount of pressure for the speed of the wheel; the vibration of the glass will cause it to crack, unless skilfully handled. The operator judges the proper pressure by feeling as much as by sight.

Elaborate pieces require several weeks for cutting and polishing and the labor cost is very heavy.

Roughing

The "roughers" are workmen who make a rough outline of the design, following the larger lines and cutting the deep incisions. This is done on steel wheels about 2½ feet in diameter. A steel wheel is also used to make the bottom of the piece level. In some cases a wheel of carboniferous sandstone is used instead of steel.

As the wheel cuts into the glass, a stream of water and sand made from garnet and hornblende trickles over it from a can suspended above. This stream of water and sand assists the cutting and makes it almost

noiseless. When the process is finished, the glass has a frosted or milky appearance.

Smoothing

When the deep lines have been cut, the design is refined and smoothed upon a wheel of black cragleith stone without the use of sand or emery. Cragleith is a famous stone from Edinburgh which contains no sand. The stone wheel, which resembles the steel one in size and shape, smooths the deep incisions and gives the glass a gray, satiny finish which enables it to take a high polish.

Another stone which is used in the process is called alundum, an artificial composition of a special kind of clay called bauxite. The clay has been subjected to an electrical current, reduced to crystals, crushed to powder, and then mixed with sand, salt, and sawdust, and burned in a kiln.

The piece now goes back to the stencil operators, usually girls, who put in the design for the finer cutting — the stars, checkerwork, light criss-cross lines, etc. This cutting is done on a stone wheel and requires great skill and accuracy.

Polishing

After the complete design has been cut, the piece is taken to the polisher, who manipulates a wooden wheel

charged with emery or rouge, a polishing material. This process removes all roughness and polishes both the cut and the uncut surface. Sometimes a hard fiber brush is used or a cork wheel and powdered pumice-stone. To give a high gloss the buffing wheel is used —a sort of pad made of pressed wool. It is covered first with pumice-stone and water and then with putty powder, both of which give a brilliant polish.

Figured Blank Glass

The next grade of " cut " glass is far less expensive. It is known as the " figured " blank glass, because while it is made of the same materials as the genuine crystal, the process is simpler. The molten glass is blown into a mold, which not only gives it the desired shape but leaves the design upon it.

The design is then sharpened and finished upon a wheel and the glass is polished with acid. The best lime blanks are treated in the same way.

Lime is much cheaper than lead. It makes a harder glass and one that is lighter in weight, but without the crystal white color, brilliancy, or clear metallic ring of the lead-potash glass. The lime blanks, moreover, are usually only partly cut; the heavier parts of the design having been pressed in and the piece merely finished off by hand. Lime-crystal blanks, however, when made of fine materials and carefully finished, produce a glass

of fine quality at about half the cost of lead glass. Trade names, such as " semicut," or " floral-cut," are given to lime blanks, which may be partly cut or only pressed.

The inferior imitation is of ordinary bottle glass made of inferior and impure materials, and merely pressed into designs which resemble cut glass. Both kinds of imitation cut glass are polished with acid rather than by hand.

Acid Polishing

The glass is carefully washed in soap and water, dried, and brushed on the inside with melted paraffin. It is then dipped three times into a vessel filled with hydrofluoric acid, which eats away the sharp edges and gives it brilliancy. After the wax has been removed, the piece is again washed with a pure soap, wiped with a linen towel, and wrapped in silver tissue paper ready for shipping.

Genuine cut glass with careful handling retains both its brilliancy and color, but glass made with lime and soda is not only less brilliant than lead-potash glass when it is first made, but if the materials are impure it darkens with age.

The acid polish is quick and clean, but it produces a wavy appearance and a peculiar hard sheen instead of the smooth, deep brilliance produced by friction on

wooden, felt, and cork wheels. Glass finished by acid polish is also more quickly clouded by moisture in the air and must be cleaned more often.

Glass-Cutting Machines

Glass-cutting machines have recently been invented which will make still another distinction, in addition to the hand-cut, partly cut, and pressed ware. These machines have not been used long enough, however, to judge of their effect on the market.

How to Judge Values

In judging of the value of any hand-made product as compared with one made by machine, there are always two things to be considered:

1. The real beauty, individuality, finish, and durability of the hand-made article.
2. A "collector's value," due to the fact that hand-made articles are more costly to make and therefore can be in the possession of only a few fortunate persons.

Both of these considerations are important in the case of cut glass. The luster, finish, and durability of hand-cut lead blanks are all greater than in any of the imitations. This beauty is partly dependent on the designs, which differ widely in their effectiveness.

Differences Between English and American Glass

Nearly all the English patterns are what are called straight or miter cuts, that is, the lines are straight rather than curved. They consist of:

Splits
Olives
Prisms
Hobnail, or blunt-cornered diamonds
Flutes
Fringes
Strawberry diamonds
Stars

Figure 8 in Chapter X shows several examples of miter cuttings.

The best English glass is called rock crystal, because of its resemblance to the clear sparkling stone of that name.

American cut glass is considered by some judges the best in the world and has been exported to Europe for a good many years; though for a long time merchants in this country were afraid to acknowledge that it was of domestic manufacture and therefore called it imported.

Fan scallops, rosettes, curved and floral patterns have been developed recently as the result of American ingenuity.

Courtesy of C. Dorflinger & Sons

Figure 7. Cut Glass Goblet in Poppy Design

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Popular floral patterns are the:

Scotch thistle
Rambler rose
Daisy
Poppy
Lily
Lotus
Grape

A combination of miter and floral patterns is often seen, in which the sides of a piece are miter-cut and the bottom decorated with a floral pattern. The miter patterns may be pressed and the flowers cut with a "mat" or frosted finish which gives the piece individuality.

Floral cutting is much more delicate and graceful than the stiff miter cutting, though the latter is very effective in large, heavy pieces. The deeper cuts are brilliant, but the lighter ones are easier to keep clean.

Figure 7 illustrates a beautiful example of floral cutting — a goblet cut in poppy design.

Cut Rock Crystal

Cut rock crystal is a very beautiful form of cut glass which has the shimmering luster and wavelike appearance of moving water instead of the brilliancy of more familiar types. It is an excellent copy of the

genuine rock crystal which is so rare that it is seldom found except in the cabinets of collectors.

The cutting is in fine, delicate, floral patterns which resemble the tracing of engraving.

Genuine Rock Crystal

A brief description has already been given of rock crystal. It is a colorless, transparent form of quartz or crystallized silica. It looks like a brilliant and beautiful form of glass, but differs from it in being crystallized. It was first found in Europe in the highest peaks of the Alps Mountains, and for many centuries was supposed to be ice frozen so hard that it could not be thawed.

Works of Art Carved from Rock Crystal

The Romans carved cups and vases of rock crystal, some of them of remarkable size, but it was used more generally in the middle ages. Altar crosses and other church ornaments were made from it, and it adorned the palaces of kings. In 1351 the throne and the footstool of a French king were made of the clear, sparkling crystal, and Catherine de Medici had a collection of magnificent vases of the same material. Some of these treasures are set with precious stones and incrusted with gold and silver.

Rock crystal is very durable and much less easily

scratched than glass. It has sometimes been sold as a diamond when cut like a gem. While it is still used in rings and pendants in some countries of the far east, it is usually found in larger pieces and ornamented with beautiful carving. The merchants of Venice probably introduced it to western Europe. It was found later in the Italian and the French Alps, and also in Hungary, Iceland, and Madagascar. The United States is now the principal source of supply.

Crystal carving is closely allied to the work of the goldsmith, and has been associated with the cutting of cameos and semiprecious stones. Though it often appears in large vessels, most of these pieces are composed of several smaller fragments joined together by gold or silver. Some magnificent specimens, however, are carved out of a single piece with no ornament except the exquisite handiwork.

There are very fine collections of rock crystal in Paris, Dresden, Vienna, Berlin, London, and Madrid. The J. P. Morgan collection, formerly at the Metropolitan Museum in New York City, and the Altman collection have been considered the finest in this country.

Chapter VII

ENGRAVED, ETCHED, AND CARVED GLASS

Methods of Decoration

The surface of glass may also be decorated by means of friction by cutting instruments. These forms of decoration are known as:

Engraving
Etching
Frosting
Carving or Embossing
Trailing

Engraving

Engraving is hand-work; the design is either cut out by a copper disc operated by foot-power or machinery or else by rapidly revolving spindles. The glass is held against the disc or the spindle by the operator's hands. Engraving is usually a line design, but elaborate scenes can be sketched by means of the spindles, as in the case of Bohemian glass. The depth and

width of the lines can be varied by changing the disc or the spindle.

Etching

Etching is done by means of hydrofluoric acid, the only acid which will attack glass. The piece of glass to be etched is covered with some substance called the "resist," on which the acid has no effect. The substances commonly used for the purpose are beeswax, paraffin, tallow, resin, rubber compounds, and metallic lead. Beeswax is quite expensive but very satisfactory because it melts easily and may be applied with a brush, and because it is also easily removed.

The two processes employed are:

Needle-Etching
Plate-Etching

Needle-Etching

For needle- or machine-etching small needles are arranged in moving arms, which pierce through the resist and outline the pattern on the glass. The machines are operated by electricity or by compressed air. The article is then immersed in hydrofluoric acid, which instantly attacks the uncovered glass. Needle-etched designs are always symmetrical—a series of straight or zigzag lines, circles, curves, etc.

Plate-Etching

This method allows much greater freedom of design, but it also requires skilled labor and is therefore more expensive. The design is first cut in a metal plate and then a print is taken from the plate on tissue paper. From the tissue paper print it is transferred to the glass, which is then coated with the resist around all of the design.

After the acid has eaten out the pattern, the wax is removed by placing the article in boiling water and steam. Ten distinct processes are required for plate-etching, but beautiful results may be obtained.

Sand-Blast Etching

In this species of etching the design is cut by means of streams of sand, which are blown against the glass by compressed air or steam. The process was invented in 1876 by a Philadelphian, who conceived the idea from the dulling of lighthouse glass by the sand blown against it in times of storm.

The glass is prepared as for acid-etching, the surface being covered with a resist such as rubber, resin, tallow, or even tinfoil or paper out of which the design is cut. The stream of sand is then applied and gradually cuts away the glass, leaving a dull or frosted surface. The effect is varied by using wet instead of dry sand, and by varying the degrees of fineness. The

finer the sand and the less the pressure of the blast, the more delicate the design. Sharp sand gives the best result. Seashore sand is ineffective, as its cutting edges have been worn away by the constant action of the water.

Frosting

Frosting is now done either by acid or the sand-blast, but was originally produced by rolling the piece in finely powdered glass while it was still soft enough to receive a thin coating of the glistening particles. Frosted glass was first produced in Bohemia, where it was designed to imitate the coating made on glass by frost in winter. The designs were therefore more like a delicate lace-work than a definite pattern. The Venetians made frosted glass in beautiful colors, but they were never so appropriate as the white frost-work.

Carving

The design is roughly outlined on the glass with acid and then cut away with small steel gravers. It is very delicate work, requiring a rather soft glass and most careful manipulation of the tools, which are either operated entirely by hand or struck lightly with wooden mallets.

Embossing

This process is the reverse of etching in that the

designs are raised on the glass. The resist is made to cover the design. When the background, left exposed, has been eaten away by acid, the design is left standing out in relief. The designs are usually large, simple, and conventional.

Trailing

Designs may be applied to the glass when it is in the viscous state by fusing fresh pieces on it instead of cutting into the surface. This is called "trailing," as the design is usually worked out in trails of vines or similar figures. It is one of the ways of applying color and is much used in Venetian glass.

Chapter VIII

TABLEWARE

The largest division of table glass is stemware which includes sherbet and grapefruit glasses, compotes, all forms of drinking glasses except tumblers, and many larger pieces for holding fruits or desserts.

Stemware

Stemware comprises those articles which consist of a bowl, stem, and foot or base. The relative size of the bowl and foot is determined by certain rules of proportion; for instance, the foot must be neither too small nor too large to look well and give the glass a proper balance. The stem may be so short that it is scarcely more than a curve between the two larger portions, or it may hold the bowl high in the air.

The finer grades of stemware are of blown glass, and these are again divided into those in which the stem is "drawn" out from the piece composing the bowl, and those which are made from three separate gatherings of glass.

Shaping Stemware

For the drawn stems, the glassblower gives the bowl its general shape by blowing and rolling, or shaping with the hand tools; he then pulls or draws out a portion of the soft glass until it forms a slender stem. The upper picture in the frontispiece shows the stem being formed.

On the end of the stem another bit of glass is then dropped, flattened out, and worked.

If the glass is made of three gatherings the bowl is blown into a mold; then another workman drops a bit of glass on the bowl and shapes a third piece for a foot, which is then flattened and shaped as in the drawn bowl.

In all blown glass the bubble is closed over the top and must be cut away with shears or on a wheel. The glass is then reheated and the edges rounded off. The lower picture in the frontispiece shows the finished piece of stemware being carried to the lehrs.

After shaping the foot the soft glass is attached to a glass knob or pontil called a "punty," while the "boss," that is, the shaped or rounded top of the bowl, is being removed.

Variety of Shapes

The shapes of the bowls vary widely. The principal ones are:

1. Drawn, usually rather pointed.
2. Straight-sided, either low and broad, or high and narrow.
3. Ovoid, or rounded like an egg.
4. Bell-shaped, with sides curving in and wide mouth.

These are only the general types, of which there are many variations.

The bowls of wine-glasses are usually plain. Goblets, compotes, and other stemware may be engraved, etched, or gilded.

Stem Variations

Stems may be:

1. Plain (straight or curved)
2. Twisted
3. Cut or " bossed "

Plain stems are the most common.

Twisted stems are made by impressing straight grooves in a rod of viscous glass and then catching the two ends and twisting them to give a spiral effect; or by fusing glass rods or canes together and twisting them. Color is sometimes added in the form of a twist " trailed " around the stem on the outside.

Cut stems may be cut in rings, in straight, vertical lines, in spirals, or in fine patterns.

The foot of a piece of stemware is not perfectly flat, but hollowed up somewhat in the middle. It may have a decoration on either the upper or the under side.

Tumblers

Thin tumblers are blown into a mold and the top is cut off in the same manner as the tops of stemware. Heavier tumblers are usually made of pressed glass, though the finest cut tumblers are of blown lead glass cut on wheels. For pressed tumblers the glass is poured into the mold and pressed by the metal plunger. They are revolved in the mold while cooling in order that they may not show mold marks. The molds for this purpose are lined with charcoal or a similar preparation. Pressed tumblers may be decorated in any of the usual ways.

If the mold has a pattern stamped in it to imitate cut glass, this revolving process is not possible. In this case, except for the cheapest grades, the mold marks are polished off. For semicut or floral-cut glass the patterns are sharpened and finished on the cutting wheels.

Sets for Many Purposes

Many articles of table glass are sold in sets.

A *water set* consists of a carafe, bottle, or pitcher and six or twelve glasses of medium size.

Iced tea or *grape-juice sets* consist of a pitcher and six tall glasses. They may also include an ice tub.

Wine, cordial, or *liqueur sets* consist of a decanter and six glasses. Cordial or liqueur glasses are very small, holding from ½ to 1½ ozs. Wine glasses hold from 2½ to 3 ozs. Cocktail and champagne glasses have a high stem and a shallow, wide bowl.

Decanters are bottles with a low, broad bowl and a slender neck. Decanters for liqueurs are small and shaped like cruets for vinegar or oil.

Water bottles or *carafes* are stouter than decanters, and are usually of heavier glass.

Sherbet sets may consist of six or twelve glasses. The stems are more slender than those of wine glasses and the bowls shallower.

Grapefruit sets consist of six or twelve large long-stemmed glasses, which may hold either the half-fruit surrounded with cracked ice, or a smaller glass which contains the fruit juice and is set in the ice.

A *punch* or *lemonade set* consists of a large bowl, a ladle, and twelve glasses, often set on a plateau or a glass tray.

Finger-bowls come in sets of six with or without saucers.

Berry sets consist of a medium-sized bowl and six berry dishes.

Coasters for use on a polished table are small, flat

glass discs with rims for holding tumblers. They come in sets of four or six.

A *mayonnaise* or a *whipped cream set* consists of a bowl, spoon, and saucer.

An *almond* or a *relish set* consists of a small fancy dish and six very small side-dishes.

Sugar and *cream sets* consist of a small pitcher and a bowl.

A *flower set* consists of a large vase and four smaller vases.

Bedroom and *toilet sets,* also called *guest* or *boudoir sets,* consist of a water bottle covered with a small tumbler fitting closely down on it.

Toilet bottles for medicines are of two standard sizes, 4 and 6 ozs., and with narrow or wide mouths, according to the material which they are intended to contain. The plain ones are of clear glass, usually square, with the name of the material they contain marked on them in black on a gold background. The more elaborate ones are decorated in enamels. Such bottles are often sold in sets of six or more, and may be fitted in a rack ready to be hung in the bathroom.

Single Articles

Many single articles are also sold in the Glassware Department.

Pitchers come in a great many styles, sizes, and designs.

Tankards and *jugs* are both a form of pitcher, the first usually high and slender in shape and the latter low and broad. Tankards are of more varied and original designs than pitchers and jugs and are used for more special purposes.

Cruets and *bottles* for holding dressing, vinegar, catsup, etc., differ in shape and size according to their use. All of them have stoppers; cruets have handles also.

Jars are wide mouthed and may be low or high. Sometimes they are squat, small, and square, though usually they are round. Sometimes they are fitted with a glass spoon and usually with stoppers or tops. Candy jars are tall, with curving sides and tops finished with elaborate handles or knobs.

Glass *bowls* and *dishes* are of infinite variety in pressed, molded, or cut glass and with every type of decoration. Salad bowls are low and broad while fruit bowls are high. Rose bowls are round with a small opening at the top.

Ice and *butter tubs* are tub-shaped glass dishes with saucers.

Compotes or *sweetmeat dishes* are stemware with flat bowls and high stems.

Other *bonbon dishes* are set flat on the table, and may be round, oval, or of any fancy shape.

Casseroles, cake, pie, and *bread pans, bean pots, ramekins,* and other kind of *baking dishes,* are made of glass ovenware, which will stand a high temperature without cracking. (See manual on "Housefurnishings.") These articles, when fitted into any standard mounting, such as sterling or German silver, make attractive dishes from which to serve. Some of the higher-priced pieces are decorated with light-cut floral designs and sold for the same purpose as cut glass serving dishes.

Glass trays have wooden or metal rims and may be transparent or backed with silk, cretonne, inlaid wood, etc.

Chapter IX

MIRRORS AND TABLE REFLECTORS

Mirrors

The process of making mirrors has radically changed since 1835 when J. von Liebig invented the silver nitrate process. Before that time the glass was backed by amalgam, a mercury compound.

Amalgam Mirrors

The silvering of an amalgam mirror is quite an elaborate process.

First a thin sheet of tin foil is spread out on a table and a small quantity of mercury rubbed over it. It is then carefully cleaned to remove dust. On this foundation mercury is poured until it is about a quarter of an inch deep and the polished glass is slid over the mercury. Heavy weights are placed on the glass and the table is tilted so that all superfluous mercury will run off. After a period of twenty-four hours the weights are removed and the glass turned with the silvered side up to dry and harden.

Silvered Mirrors

The real silvering of glass which has largely taken the place of the amalgam method is done with a solution of silver nitrate and ammonia. The silver nitrate is dissolved in an equal quantity of water, and ammonia is added to it. Then a very small quantity of potash and more ammonia and silver nitrate are added.

This mixture may be applied in two ways—by the hot or the cold process. In the former the glass is placed, polished side up, on a double metallic table heated by steam. The silver solution is combined with tartaric acid and poured over the heated glass. When dry it is protected by a coating of shellac, copal varnish, or red lead or is electroplated with copper.

Telescope discs are silvered by the cold process. In this the silver nitrate solution is combined with a solution of sugar, water, and alcohol. The disc is placed on a rocking table and the mixture poured on, making a thick film. The water is allowed to remain for some time until the deposit has settled. The mirror is then cleaned with alcohol and burnished with chamois and jeweler's rouge. The silver forms the reflecting surface.

The amalgam mirrors are more permanent than silver, less affected by sun, heat, and dampness, but the mercury fumes are very bad for the workmen.

Platinum Mirrors

Platinum mirrors are made with a very thin film of chloride of platinum applied with a brush and fired in a kiln. They are grayish in color and are chiefly used in fancy boxes and similar articles because of their cheapness.

Plateaux or Table Reflectors

Plateaux are plate glass mirrors which are used as bases for centerpieces, punch-bowls, or other table furnishings for decorative effect. They add greatly to the brilliancy of cut glass by increasing the reflection of light from its many facets.

Plateaux are either round or oval and range from 8 to 20 inches in diameter; the larger ones are used for punch sets or similar purposes. Some reflectors rest directly upon the table; others are raised on ornamental feet made of the same material as the rim.

The outer edge of the glass is bevelled, the ridge being usually one-fourth or one-third of an inch wide; but in expensive pieces it may be an inch or more; sometimes the edge is cut, engraved, or etched. Serving plateaux have a rim of metal raised above the edge of the mirror in order to prevent glasses or cups from slipping off.

The rims of these table reflectors are made of sterling silver or white metal silver-plated. The under

side of the reflectors is covered with thick paper, felt, or leather. An inner lining of thick cardboard serves to pad the glass and protect it.

Ancient Mirrors

Ancient mirrors were of metal—bronze or silver—though some glass mirrors were coated with tin. Glass mirrors were used in the Middle Ages and Venice made them on a commercial scale in the fifteenth century.

Chapter X

DESIGN IN GLASSWARE

Fundamentals of Design

In designing glassware two elements must be considered: shape and decoration.

Importance of Shape

On the flat surfaces of textile materials design can be expressed only in pattern, but each article made of glass has an individual shape which is the most important element in its design.

Many people who make and handle glass do not seem to appreciate this fact. They do not pay any attention to form, but proceed to heap decoration upon ugly and awkward pieces in order to make them beautiful. No amount of decoration, however, can do this. It often only emphasizes the ugliness it seeks to conceal.

The beautiful and tractable material which we call glass deserves artistic treatment and amply repays the artist who gives it his most careful workmanship.

But the fact that it is so essentially beautiful has made stupid and vulgar designs marketable, whereas if they had been made of less shining material no one would have looked at them.

Like all other materials, glass is most beautiful when treated according to its own nature and not made to imitate something else. Glass made by the Phoenicians and the Romans was molded on a core of sand and the shapes of these old vessels are not unlike those made of pottery. They are often graceful but lack the delicacy which we associate with glass. The discovery and perfection of the art of glass-blowing made possible a new and distinctive form of art.

Shapes of Cut Glass and Blown Glass Articles

Modern glassware may be divided into two general groups: heavy and substantial pieces whose decoration is cut deeply into the metal, and " blown glass " which is shaped by the expansion of air and finished by gentle manipulation while in the plastic state.

While of course the best cut glass is made from blanks which are blown into a mold, when we speak of blown glass we mean the thin and apparently fragile types which show that they have had delicate handling.

The difference in process determines not only the shape but the type of decoration suitable to it.

Heavy cut glass is made in simple, well-proportioned

shapes, and depends for its beauty upon the jeweled effect and the refraction of light produced by the deep cutting.

The shapes of blown glass pieces may be simple also, differing but little from the lighter kinds of cut glass, but on the other hand they may be elaborate, and so delicately fashioned that stems or handles may be easily snapped with the fingers. Their decoration should be correspondingly dainty and fine.

Purpose for which Article Is to be Used

The shape of any article should be adapted to the purpose for which it is to be used. When glass is intended for practical purposes as well as for ornament, those purposes should be given careful consideration.

Pitchers are made to hold liquids. They should therefore be well balanced so that they cannot be easily overturned. The handle should be so constructed that the pitcher will tip at a convenient angle and the spout or lip so shaped that the contents of the pitcher will pour through it and not over its edges.

Stemware for drinking glasses should have stems which may be comfortably and securely handled. The ridges on heavy glasses are partly for this purpose, but light wine glasses do not need such aids. The bowls of drinking glasses are also shaped according to their use.

The shapes of large bowls and flat dishes should be determined in part by the kind of food or drink which they are to contain.

Vases are of many shapes because flowers require different settings. Roses and violets, lilies and carnations cannot be properly arranged in vases of the same shape.

Traditional shapes for glassware are usually good, but they may easily be vulgarized by the change of a curve, the shortening of a stem, or the addition of some meaningless detail. Only the practice of studying pieces which are known to be beautiful will train the eye so that it will recognize beautiful lines and forms.

Designs for Cut Glass

As the blanks for cut glass must be thick enough to stand the pressure and the grinding of the wheels, they naturally have a somewhat massive appearance.

Old English cutters increased this massive effect by the simple shapes of their glassware and the straight lines of the miter or hobnail patterns. The pieces in Figure 8 are fine representatives of this type of cutting. Notice the curving lines sweeping upward over the shoulder of the vase and the dignity in each of the shapes.

Courtesy of A. Gredelue

Figure 8. Patterns in Miter Cutting

The miter cuttings are either faceted like jewels or molded in simple blunt designs.

The American floral cuttings are of several kinds. Some of them are as deep as miter cuttings and require a heavy blank, while others are shallow enough to resemble etching or engraving. The deep floral cuts are also combined with miter cuts or with light frosted floral designs.

In order to conform to the general laws of design, great care must be taken to adapt the cutting to the shape and purpose of the piece of glass to be decorated. For example, the cutting on the lip of a jug or pitcher should be in lines radiating from its base to the edge. They should never cut across it. This applies also to cutting in the handle which should either be spiral (suggesting a continuous line) or follow the curve of the handle even more closely.

Sprays of flowers or leafage springing from the straight line at the base of a bowl or pitcher are abrupt and awkward, while an upright conventional pattern is satisfying.

A branching spray may be graceful when it appears to start from the stem of a goblet, especially if it follows the general line of the glass.

In some designs the cuttings are so deep as to break completely the outline of the piece and make it appear ready to fall apart.

Another defect is found in the use of patterns in straight bands which cross the article at any angle and even stop abruptly in the middle of a side. Straight lines are needed to steady a pattern, while curved lines give it grace and lightness. Such bands of ornament, however, are always noticeable and because they are stiff and aggressive they should follow the outline of the piece like a border. When they run all over the side they look like bands of embroidery trimming out of place.

Individual cuttings should be proportioned to the size of the article. A single flower should not cover the whole side of a pitcher or vase and a star should not look like a rising sun. Small patterns usually give a more artistic effect, but they should not be so cut up with crossing lines as to look confused.

Standard Cut Glass Patterns

Among many admirable patterns in cut glass are:

Colonial designs with simple geometrical divisions following the outline of the article.

Small separate designs repeated on a plain or "mat" background.

Light floral cuttings usually much conventionalized and sometimes frosted.

Old English miter and hobnail patterns.

Some combinations of miter and floral patterns are effective but they must be treated with care. They are successful only if the flowers are so conventional as to become a part of the miter pattern, or if the miter pattern is so unobtrusive as to form a background or frame for the flowers. If the stiff lines of miter cutting are alternated with sprays of flowers so that each form of cutting is thrown into relief, all unity of design is lost.

Engraved Glass Patterns

While deep cutting gives glass the brilliancy of jewels, the designs are restricted to formal and conventional patterns. Light floral cutting is a freer form, and engraving or etching may be given infinite variety because it is essentially a surface decoration.

In criticizing the patterns in engraved glass we need not consider the hard material or the difficulties of workmanship; we ask only for graceful outlines, clearness, unity, and suitability. The greater freedom which is given to a designer of engraved glass does not, however, release him from the laws which govern all design or pattern-making.

Laws of Design

Some of these laws may be stated simply. First the elements of a pattern, that is, the figures, are either:

Natural — imitating nature as much as the material will permit.

Conventional — suggesting nature but simplified and adapted to the purpose of the decoration or the pattern.

Abstract — made up of repeated lines and patterns which have no intentional resemblance to natural forms. (Sometimes it is hard to draw a clear line between very much conventionalized nature and abstract patterns.)

Elements of Design

Pattern designs are made up of lines, forms, and spaces.

1. There must be a center of interest. In a standing piece of glassware this should usually be at a point a little above the middle of the article. In a bowl or flat piece it is either in the middle or at the handle end. The pattern may radiate from this point or it may only be given a little more emphasis there.

In the case of simple borders or of repeated all-over patterns the shape of the article is made the center of interest to which the pattern calls attention.

If the pattern starts from the base as in many goblets, pitchers, and vases, the plain upper part is still a part of the design and is thrown out in relief like

the broad petals of flowers springing out of the more complicated cup or calyx.

2. The pattern should be well distributed and have a proper balance. This is especially important if the pattern is repeated a number of times, as a balance good enough for a single composition may not be good enough for repetition.

3. The parts of a design must harmonize and be well bound together. The crossing of a design from one part of a piece having several sections to another is always effective. For example, the extension of the pattern from the stem to the bowl of stemware or from the handle to the body of a jug or pitcher gives a sense of unity and pleasure.

Certain other principles of design contribute to the beauty of a pattern. Some of these are:

Gradation, by which repeated forms vary in size.

Symmetry and contrast, by which the design is given unity and variety.

Radiation, which gives the eye a sense of completeness. In nature flowers, wings, and shells all have these beautiful radiating lines.

Composition of line, which is the term given to the arrangement of lines so that they flow into one another; and even when the ends of the lines do not connect, the eye is guided by their general direction to the points of interest.

Good Design

In judging the different types of decoration, certain guiding principles should be recognized.

The decoration should be suitable to the material and to the manner in which it is worked.

Decoration should add interest to the article decorated. It should be appropriate to the purpose of the article. The artist should always strike a balance between use and beauty. Very elaborate decoration is better suited to articles that are intended only for ornament than to those which are to be given hard daily use.

Decoration should always bear a direct relation to the structural lines, that is, to the shape of the article. The pattern should either follow those lines or bring out their beauty by contrast.

The Use of Color in Design

The principles of design which apply to cut and engraved glass are no less important when the decoration is in gold, silver, or colored enamel. Patterns which are given emphasis by any of these means should be even more carefully designed than those which are less noticeable.

Nothing is in poorer taste than a cheap and tawdry design worked out in heavy gold or colored figures.

Old Venetian glass is the best example of elaborate

designs produced by the use of color. Its stripes and figure patterns, festoons, and lace-work show the marvelous possibilities of the plastic material. Some of these elaborate designs, however, are not beautiful but merely curious. Modern Venetian glass has fewer varieties and American copies of this glass are still simpler, having much less grace and delicacy of outline. This is due in part to the greater hardness of the metal of American glass and in part to the greater haste in production which leaves the workman no time for individual treatment of his material.

When colored glass is transparent or translucent it has a unique beauty which requires the most sympathetic treatment.

Part III—Decorative Glass

Chapter XI

METHODS OF DECORATION

Possibilities of Glass

Glass is a material with almost unlimited possibilities for the making of beautiful things. As we have seen, it may be blown, cut, or molded into the most exquisitely graceful shapes, while its transparency, crystal clearness, and bright surface make it second only to the diamond in its reflection of light and the prismatic colors which it scatters.

In nearly all its forms glass is more or less ornamental, and attempts are usually made to give even the commonest articles, such as bottles, glass mugs, or pitchers, a graceful shape and some kind of decoration. Most exquisite effects are produced with glass, moreover, in the hands of the true artist. Among the priceless treasures of ancient and modern times may be found many specimens of beautiful glass.

Colored Decoration of Glass Surfaces

The various methods of decorating the surface of glass are:

Gilding
Painting and enameling
Lacquering

Gilding

Gilding is an old form of glass decoration. It is done by the application of gold-leaf, liquid gold, or bronze powder. There are three methods of gilding:

Gold resist
Gold banding
Application of gold-leaf

Gold Resist

The gold resist method is a combination of etching and gilding, as the design is first eaten out by the acid and then filled with gold. The piece is fired to unite the gold with the glass, and the design is burnished with a hard, smooth stone for a bright finish, or with spun glass or fine sand for a dull finish. The gold may be what is called "liquid bright" gold, which is gold bullion melted down in an acid so that it may be applied with a brush.

Gold Banding

Gold banding is more simple than the gold resist method. It may be done with the same gold solutions, or a cheaper bronze powder may be used. The article to be banded is placed on a revolving disc, and the workman applies the solution with a brush as it turns before him. Banding may also be done by machine. The gold is burnt in and burnished as with the resist method.

Gold-leaf

Gold-leaf is gold beaten out extremely thin. It may be reduced to $\frac{1}{250,000}$ of an inch in thickness. It was formerly used for gilding but is now replaced by the two other methods. The gold leaf was attached to the glass by means of thin wax or glue and fired until it became fused upon the glass.

Painting and Enameling

Enameling is decorating glass with color by means of designs painted by hand in opaque glazes or enamels which unite with the glass when fired. The name is also given to a method of transferring printed patterns made of these materials to the glass by pasting them on and then firing the piece.

Lacquering or Japanning

This is done in the same way with cheaper materials mixed with shellac or varnish and baked on the surface. It is an inexpensive and showy form of glass decorating.

Silver Deposit Glass

A very pleasing division of the Glassware Department is the silver deposit glass, which is found in vases, water sets, wine sets, and other articles. The chief decoration is silver, which is overlaid upon it in graceful patterns. The foundation is of plain glass and sometimes has fine stone cutting covering the space which is not silvered.

Process of Manufacture of Silver Deposit Ware

The blanks for the silver deposit ware are designed to fit the decoration which is to be applied and are made to order in large quantities for the cut glass factories.

The process of manufacture from these blanks consists of:

Sketching the pattern
Firing the design, to form the base for the silver
Electroplating
Polishing
Engraving

Sketching the Pattern

The designer outlines the decoration on the blank with either a brush or a stencil pattern. The material used for making the design is a metallic silver solution composed of silver 99.9 per cent pure, nitric acid, and other chemicals. It is a dark gray substance of the consistency of thick paint. The coating is allowed to dry before the next or firing process.

Firing

The pieces are arranged on shelves in the kiln and the fire, usually of gas, is lighted. The temperature is gradully raised to 1200° C., a cherry red or white heat. This takes two hours or more; the whole process of raising and lowering the temperature requires about four hours. During the process of firing the metal of the design melts and unites with the glass, which has also been softened by the heat. The design is white when it comes out of the furnace and is the surface for electroplating.

Electroplating

After the pieces have cooled to a normal temperature they are suspended on copper or brass rods in a tank filled with a solution of nitrate of silver. The rods are connected with the negative pole of a mag-

neto-electric machine. On rods in the center of the tank are suspended bars of silver 99.9 per cent pure, connected with the positive pole of the machine.

A current of electricity passed through the solution causes the tiny particles of silver in solution to arrange themselves on the metallic surface of the design. The rest of the glass is unaffected by the process as the silver will attach itself only to the metallic surface.

The pieces are left in the solution from 1½ to 24 hours, according to the desired thickness of the deposit. Sometimes a thin band is deposited and sometimes a heavy coat suitable for engraving or cutting. For ware of the best quality the silver deposited by the electroplating process is also 99.9 per cent pure. The design is still white when it is removed from the tank and remains so until it is polished.

Sometimes a colored background is produced by covering the inside of the article with a colored enamel and firing the piece again. A backing of gold may be applied, which makes the design silver on one side and gold on the other.

Polishing

The polishing process is in two parts.

First the workman holds the piece against a rapidly revolving, coarse, buffing wheel made of canton flannel softened by grease. This cuts down and smoothes the

surface of the silver. The tiny particles which are rubbed off by the wheel are collected by suction and purified for later use. This process is called surface buffing.

The second buffing is given with a softer buffing wheel covered with rouge. This gives the silver a high luster.

Engraving the Silver Deposit

There are two methods of brightening the design or adding to the delicacy of its detail. True engraving is done in the same way as other engraving on silver or gold, with delicate tools and most careful workmanship. The deposit must be reasonably thick and not too hard for the purpose. Engraving on silver deposit requires great care because of the brittle glass background.

The other process is known as imitation engraving. In this the workman scratches away the metallic silver of the sketched design with needles of varying degrees of fineness. When the piece is electroplated the silver is not deposited along the lines thus scratched. The true engraving is distinguished from the imitation by the delicacy and accuracy of line.

Original Process

This artistic and popular form of decorated glass

originated in France where the process was at first very elaborate and costly. The piece of glass was first coated with a suitable chemical to make the metal adhere to the glass and then electroplated with silver all over. The silver was then cut away from the design with hand tools. This early method, with some improvements, was followed until the present one was invented.

Meaning of the Term " Art Glass "

All glass which has been given graceful form and artistic decoration might be included under the title " art glass," but that which is cut, engraved, or ornamented with gold or silver is usually classed under those heads.

The name art glass is generally applied to glass which is artistic not only in shape and design but is remarkable also for its beautiful color or mixture of colors. Sometimes the color is fused on the outside after the piece is formed; but in the most characteristic forms — the Venetian, Bohemian, and Tiffany glass — the color is introduced into the molten glass.

Expert chemists are constantly at work discovering new combinations and methods of treatment which will produce new color effects. If two coloring oxides are used together, their union produces a new color which may not resemble either; by the multitude of

these combinations the color scale of glass is rendered almost endless.

Colored Glass

Some of the popular forms of art glass are known under names denoting their color or their distinguishing quality, as:

Amber	Mahogany
Wisteria	Black
Mulberry	Dark blue
Green	Rose
Opaline or opal	Cream-colored
Moonlight iridescent	White
Verre de soie	Metallic luster
Pearl luster	Gemmed or sealed
Calcite	Stained glass

Amber glass is a clear brownish-yellow. It is found in tableware such as sherbet cups, thin wine glasses, and ornamental pieces, and also in vases of various shapes.

Wisteria or *mulberry glass* is a rich but somber purple which has become popular recently. It is used almost entirely for decorative glass.

Green glass is attractive even in an inexpensive quality and is much used for vases and fern dishes.

Opaline or *opal* glass has a shimmering changeable

effect, caused by the application of metallic oxides to the surface of the glass. It is known as moonlight iridescent, verre de soie, pearl luster, and calcite.

Moonlight iridescent is a transparent, faintly opaline glass resembling the old Bohemian in its play of color.

Verre de soie is a French glass almost transparent but slightly milky with a delicate pearly luster suggestive of silk. It is called plain when of a pure white satiny finish or when only faintly opalescent. The colors are soft, pale lavender, green, and blue. It is often engraved with a light cutting.

Pearl luster is similar to Verre de soie, but is heavier and of less delicate colors. It is also more opaque. The pieces are often decorated with gold banding or designs etched in gold.

Calcite is a brilliantly opalescent, opaque glass suggesting the more gorgeously colored Tiffany glass. The outside is creamy white and the inside has a beautiful play of warm yellow, orange, green, and purple.

Mahogany glass is one of the most recent popular forms of colored glass. It is made in flower bowls, fern dishes, vases, candlesticks, and other articles of decorative ware, either plain or ornamented with gold and silver. The glass is a deep brown or mahogany color with wavy lines to imitate wood graining.

Black glass has had a vogue which is hard to understand, as it is inappropriate for table decoration and is

at all times a somber background or setting for flowers. The funereal effect is somewhat lightened by decorations of bright colored flowers, but its popularity will not last after the novelty has worn off because it has few of the characteristics which give glass its beauty and charm.

Dark blue, rose, and *deep cream-colored glass* may be seen in a large number of decorative pieces, some of which are very dainty and soft in tone.

White glass is often ornamented with lines or bands of color and color is put on in the trailed decorations, handles, and finishing touches. In these cases the added colored glass is previously prepared in the form of short rods, which are reheated and applied as the design requires.

Metallic lusters may be produced by placing particles of metal on the glass and fusing them into it. The fumes of stannous oxide will give glass an artificial iridescence by coating it with a thin layer of metallic tin.

Gems or *seals* are made by dropping molten glass on the vessel while it is still soft and pressing it with metal seals.

There is only one real stain for glass, which is called "silver stain" (see Chapter XVII). The term is applied to glass which is either colored in the batch with "pot metal" color or painted with enamel colors for windows.

Flashed Glass

Flashed glass is made by placing a very thin layer of deep ruby-colored glass upon the surface of a sheet of colorless glass of ordinary thickness. This is done by mixing the two kinds of glass in one gathering which, when blown, produces this effect. Other colors are also used for the flashed glass process, though ruby red is the most common. Flashed glass may always be detected by looking closely at the edge of the sheet, when the thin layer of color is plainly evident. It is in reality a veneer of color laid upon one side of a sheet of glass and may be removed in many cases by an acid or an abrasion. Flashed glass with several layers of different colors opens up a wonderful field to the decorator and the cutter.

Chapter XII

VENETIAN AND BOHEMIAN GLASS

Beauty of Design and Coloring in Venetian Glass

In the section of the department devoted to art glass, pieces of Venetian glass immediately attract attention because of their daintiness, faint, delicate coloring, and artistic designs. Some seem to be scarcely more than thin brilliant bubbles of glass; others are more solid but with strange lines, twists, and flutings of color which have been introduced apparently by magic.

For the table there are decanters, glasses, cups, plates, finger-bowls, and many varieties of compotiers, bonbonnières, and baskets for holding fruit or flowers. For the toilet table are scent bottles, powder boxes, and other dainty accessories; while urns, candlesticks, and innumerable vases seem designed for beauty alone rather than for any sort of use. Among other fanciful decorations may usually be found reproductions of natural-colored fruit in thin, transparent glass.

Venetian glass has been celebrated for more than

a thousand years for its graceful and delicate shapes and beautiful coloring. Though the industry has died down several times, it has been revived again and again. It flourishes today on the Island of Murano, from whence importations have been regularly obtained by merchants who carry fine lines of glassware.

Composition

Venetian glass is composed of:

Silica
Soda
Lime
Potash

It lacks the brilliancy of lead glass, but its colors are exceedingly soft and beautiful and its luster is very deep and permanent. This luster is the result of many reheatings, some pieces being put into the furnace as many as fifty times. It is highly fusible and therefore may be blown very thin and is readily molded into artistic shapes. It is also very light and fragile, though if reheated many times it becomes tougher than it appears to be.

Curious Shapes

The old Venetian workmen made many fantastic shapes, such as drinking glasses which resembled ships,

whales, lions, or birds. Modern manufacture is less grotesque, but birds and fruits are common forms of decoration. The dragon is a favorite figure always, showing perhaps a strong Oriental influence.

The materials in Venetian glass are seldom pure, and it is therefore apt to have a faint tinge of yellow; or if manganese has been added to neutralize the iron, it has a faint purplish hue.

The Venetian glassmaker is an artist as well as a skilled artisan. As he stands before the working hole of his furnace, blowing his airy bubbles, tossing them up and down, and twisting and fashioning the delicate stems and handles, he gives each piece an individuality and charm which can be achieved only as the result of affectionate care and pleasure in his work.

Process of Formation

In making a vase, the body is first blown and then the piece is shaped to form the foot. It is reheated and the neck widened and shaped; the tube for the handle is formed and fastened to the body; and it is again heated and given its final form. It may have a coil of glass around it from which the head of a dragon is deftly molded; or fruits and flowers of colored glass may be fused on, as the handle and foot have been.

An interesting feature of Venetian glass is the introduction of color in fine lines or spirals which seem to be embedded in some miraculous way in the material. The process is complicated, but not hard to understand.

Rods or " canes " of glass are made first by dipping the blowpipe into colored glass, drawing it out, marvering it into a cylinder 2 or 3 inches in length, and then dipping this glass cylinder into clear glass, which forms a coating all over it. This cane is 2 or 3 inches in diameter, and as broad as it is long, when the process of drawing is begun.

One workman holds the end of the cane on his blowpipe, while another grasps the other end and walks slowly away, drawing it out until it is 420 yards in length and $\frac{1}{25}$ inch in diameter, with a thin thread of color in the middle. In some cases the colored thread is wound around a rod to make a spiral before it is dipped in the clear glass, but the drawing out is the same. These canes are cut with shears in desired lengths and may be used in various ways. For a vase the canes may be placed side by side to line a mold, and a thin glass coating blown in the center to unite them. The piece is then reheated in the furnace and worked, and finally is cut off with pincers which press the canes together at that point.

Filigree Glass

A filigree glass called *reticelli* is made by placing side by side a series of transparent rods or canes, each containing a twisted thread of colored or milk-white glass. The rods are then heated until they are fused into a single sheet of glass with a ribbed surface. Two sheets made in this way are laid across each other, slanting so that a small air space is left between the rounding edges of the rods at each intersection. The sheets are then grasped with iron pincers and held in the furnace while they are twisted and formed into a vase. The effect of the bubbles of air inside the mass of glass, increasing and decreasing in size according to the shape of the piece, makes the manufacture seem almost incomprehensible.

Cameo Glass

Cameo glass is made by fusing a sheet of colored glass upon one of a different color, so that they can be cut in cameo effects.

Mosaic Glass

Mosaic glass is made of white threads on a blue ground, laid in mosaic patterns.

Frosted Glass

Frosted glass is made by rolling the soft piece in either white or colored powdered glass.

Gold is sprinkled over the surface by a similar process.

Laticella Glass

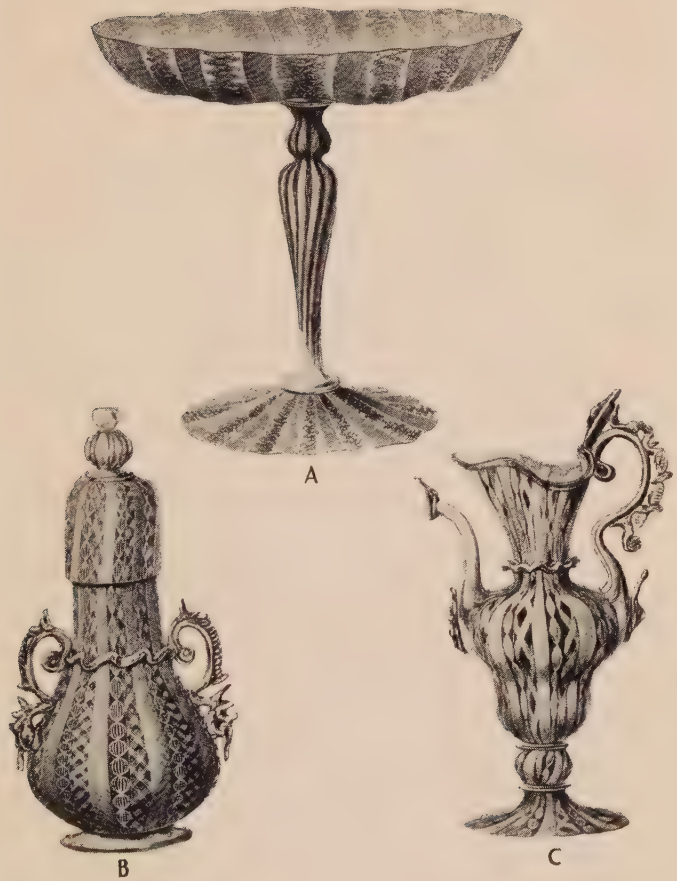
Laticella glass is decorated with open network designs. These designs are cut out of metal or paper and placed on the glass; they are held in place by essence of turpentine. A light powder is first sifted over the pattern and then it is removed. When the glass is heated the powder is melted and acts as a resist to the acid, into which the piece of glass is then dipped. The acid eats away the uncovered part of the glass, leaving a delicate lacelike pattern where the powder has been.

Millefiori Glass

Millefiori glass has small bunches or baskets of flowers in natural colors, portraits, or fanciful objects enclosed in cubes, domes, or balls of glass. This type of glass is used in paper weights or other small articles.

Coloring of Venetian Glass

This exquisite glassware has an almost unlimited range of colors, and these are equally beautiful, whether transparent or opaque. The best models are probably those that are made solely for ornament rather than as parts of table service. The lovely color-



A—Tazza B—Small Covered Vase C—Biberon

Figure 9. Examples of Venetian Glassware

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ing and original shapes look best when given a setting of their own and when they are not mingled with incongruous pieces of other types.

American manufacturers, after many years of experiment, have learned to make glassware which has most if not all of the characteristics of Venetian glass. One such manufacturer reproduces old patterns, even including the bubbles which are found in many old pieces. The old colorings such as turquoise, royal blue, and amethyst, are also found in these beautiful reproductions.

Figure 9 gives three examples of beautiful Venetian glass. Figure A shows a flat ornamental shallow cup known as a tazza. The shallow bowl is embossed to form a series of wavelets with angular points round the margin. The supporting stem is gracefully drawn with a conical foot formed of lace glass.

Figure B shows a small covered vase beautifully decorated with fine white lace-work. The wings or handles have been given the form of conventionalized dragons.

Figure C is an example of a biberon or pitcher. It is distinguished by a scalloped mouth and the medallions surmounting the handle and at the base of the spout. These medallions are ornamented by gilt satyr heads and are characteristic of the Venetian style.

Bohemian Glass

Modern Bohemian glass, which is made in Bohemia, Saxony, Bavaria, and Silesia, is usually colored or has color associated with it. It is generally heavier than Venetian glass, and in many cases the color is "flashed" or put on in thin layers, which are partly cut away, showing the clear crystal beneath.

Bohemian glass is found in table glass, such as stemware, bottles, decanters, pitchers, flat dishes, and many forms of ornamental glass.

The sand and potash from which Bohemian glass is made are very fine and pure and give it great brilliancy and lightness; because of the greater purity of its materials it is clearer than Venetian glass. The shapes of Bohemian glass vessels are less original, but often more serviceable, than the Murano pieces which they originally imitated.

Methods of Ornamentation

The best developed form of decoration is engraving, which is done on the white crystal or on flashed glass with equal effectiveness. A Bohemian named Casper Lehmann invented the method of engraving by holding the piece of glass against the points of whirling spindles.

Designs are also etched with fluoric acid; but the etched glass, while cheaper, is not so satisfactory, be-

Figure 10. Example of Bohemian Engraved Glass

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cause the designs cannot stand out so clearly and sharply.

Besides the usual floral and geometrical designs, Bohemian glass is sometimes decorated with elaborate pictures, such as hunting scenes in medallions surrounded by scrollwork.

Cutting is done in conventional patterns, especially with flashed glass, which gives a very striking effect; cameo incrustation and enamel painting are also used.

The usual colors of Bohemian glass are deep red, blue, green, and amber. Besides the "pot metal" colors which are mixed with the molten glass and the flashed colors put on as a casing, color is applied with a brush and fixed by firing the piece as with china.

History of Bohemian Glass

During the eighteenth century Bohemian glass became more popular than the Venetian product and was exported to England, America, the East, and even to Italy. Some famous pieces are now to be found in museums and private collections. It was highly prized by the early Americans, and after a period in which it went out of fashion, it has again become popular because of its genuine merits, particularly its deep rich color, its original and finely executed designs, and its serviceable styles.

Figure 10 shows a rare specimen of Bohemian en-

graved glass of medieval workmanship. It is a shell-shaped cup with deep cuttings which form a series of bold, projecting compartments. The curved surfaces of these are beautifully engraved with figures, scrolls, and other ornaments.

Chapter XIII

TIFFANY FAVRILE GLASS

Old Industry Revived

In Tiffany favrile glass we have a modern production which combines the beautiful rich colors in old cathedral windows with the surface iridescence of the ancient Egyptian and the Roman glass that has been buried in the earth for so many centuries.

Window Glass

After a number of years of experiment during which Mr. Tiffany had the glass made for him, he established his own factory in 1892 at Corona, Long Island. Large panes of flat glass, some of them with delicate opaline colors and many different kinds of texture and degrees of density are produced. Some glass is clear, some crinkled or veiled, some clouded or speckled. The varieties of color combinations and textures are too numerous to mention.

The colors for this rolled glass are all put into the batch while in its raw state. In other words, it is not *enameled* on the surface. The color is an integral part of the mass itself.

There is other glass, however, which is still more beautiful and varied. The hot glass from different pots is thrown out on the table with a ladle; as many as seven different colors may be thrown together. The famous drapery effects are made by taking advantage of natural conditions while rolling and catching the ends of the hot sheet with iron hooks and crinkling it together.

The color formulas are secret, but they are composed of different metallic oxides combined to form different tints and hues. Gold, copper, iron, and other metals are used lavishly, and the layers of glass are sometimes so heavily charged with these oxides that they are more like metal than glass.

Peacock Glass

Early in the production of favrile glass the wonderful iridescence of the peacock feather inspired Mr. Tiffany with a desire to reproduce it in glass. Many attempts were made before success was achieved. The remarkable color variations were produced in each case by the application of different colored glasses, having different chemical constituents in order that they might produce not only the diversified iridescence, but have also the characteristic body colors.

All the colors of peacock glass are applied during the process of manufacture while the glasses are in a plas-

tic or viscous condition, and the object is finished before it is placed in the annealing oven. Particular attention is drawn to this fact, for the reason that all imitations of Tiffany peacock vases have been made by the application of enamel colors after the piece is completed.

Shapes

The blown glass for table use and decorative glass is fashioned in graceful shapes which are less fanciful and odd than Venetian or Bohemian productions. They look more like Greek or Japanese designs.

Flower motifs are used for smaller pieces with the fine veins and threads of color pulled and twisted by hooks during the forming process.

The iridescence of antique glass is due to decomposition of the surface brought about by chemical action during the long period of exposure to the air. The iridescence is not permanent and may be rubbed off. In favrile glass this iridescence is reproduced in the texture of the glass by a secret process and is permanent.

Characteristic Colors of Tiffany Favrile Glass

Some of the characteristic and unusual color effects in Tiffany favrile glass are:

Gold Lustre, an iridescent old-gold coloring.

"Samian Red," the red of a lobster's claw.

"Mazarin Blue," a deep, rich blue with a purple shade.

"Tel-al-amana" or Turquoise Blue, shading from turquoise to peacock green.

"Aqua Marine," the color of deep water with bronze lights in it, or pale green with objects apparently floating in water.

In spite of its apparent delicacy, the glass is tough and durable. "Favrile" is a coined word derived from "fabric," or "fabrile," and means "made by hand."

Chapter XIV

VASES AND CANDLESTICKS

Varieties

There are two kinds of vases, those which are intended to hold flowers and those which are solely for ornament. The flower holders are usually made of glass and are shaped according to the kind and number of flowers to be contained.

The low shapes are:

Low round bowls, sometimes very shallow.
Round bowls with an irregular edge.
Bowls with a flaring, ruffled edge.
Bowls with a collar or ruffle turned over.
Rose bowls.

The medium height shapes are:

Straight-sided.
Flaring slightly.
Flaring widely.
Funnel-shaped, with a stem supported by a standard.
Baskets.

Curved gracefully in about one-third of the distance from the top and then out again in a flowing curve.
Very slender, for single flowers.

The tall shapes are:

Straight-sided column.
Flaring from a point near the base.
Flaring at the top only.
Very slender, for single long-stemmed flowers.
Same as in those of medium height.

Table Vases

Sets of vases may consist of four, five, or six vases of similar shape for table decoration. The vase intended for the center is of a larger size than the others. They are often connected by a glass chain.

A table decoration which is a revival of an old French pattern consists of a silver or gilt standard holding vases shaped like horns of plenty and connected by ornamental festoons of the metal.

A very graceful table vase consists of a low, broad bowl with a flower-like vase springing from the center.

These flower holders may be found in cut, pressed, and art glass and in a number of colors — white, green, amber, mulberry, blue, black, and opalescent. The clear, delicately tinted or white glass is in better

taste than highly ornamented glass for this purpose, as the vase should be only a setting for the flowers and should not call attention to itself.

Ornamental Vases

Ornamental vases are of many graceful shapes, but are often quite unsuited for holding flowers. They may be elaborately decorated with gold and color, and are sometimes made of several different kinds of glass. Tiffany glass is often found in forms resembling flowers, either colored to make the resemblance more complete or covered with delicate tracery.

Glass Candlesticks

Candlesticks of glass are usually of simple forms. They are:

- Four-sided
  - Straight
  - Smaller at the top
  - Curved out in the middle
  - With the corners cut off
  - Faceted
  - Rounded
- Six-sided, usually straight
- Cylindrical
- Twisted

The bases usually follow the lines of the stems, and are four- or six-sided, cut off at the corners, or round; but sometimes they are simple in order to balance an elaborate stem, or ornamented to set off a plain stem. Bases of candlesticks should be large enough to support the stick and the candle above it. They are therefore rather broad and heavy.

While candlesticks are sometimes found in colors, they are nearly always of white clear glass with plain or light frosted cutting. The bases are frequently cut underneath. The straight-sided Colonial candlestick has no ornamental cutting. Shapes which are less severe may have floral or star designs, but they are simple in style. The patterns are often acid-engraved or etched.

Candelabra of glass are hung with pendants of prisms ending in diamond points, which catch the light and increase their brilliancy by reflection.

Candlesticks for the dining table are usually of glass or silver as they then correspond with the table furnishings.

Miniature candlesticks are used for the dressing table and for children's dressers as well as for children's parties.

Chapter XV

LAMPS AND LIGHTING FIXTURES

The Lamp Department

A Lamp Department includes many varieties of lighting standards and fixtures. The illuminant may be oil, gas, or electricity, and the illuminating devices may be:

Lamps
Candles
Lanterns
Wall fixtures
Ceiling fixtures

Lamps

Oil lamps are portable because they are independent of a central lighting plant. A good oil lamp is also less trying to the eyes than the more concentrated electric light, but on the other hand oil lamps are much more troublesome as they need frequent refilling and cleaning. Oil is seldom used in wall or ceiling fixtures except on shipboard or in the country, as storage bat-

teries now supply electricity even for the lights of moving trains.

Gas, which may be supplied by means of rigid pipes, is more widely used in wall or ceiling fixtures. The flexible tubes which are needed for table lamps are made of rubber, covered with woven textile tubing. The tubes are easily cracked when bent, are rather stiff and unwieldy, and not very durable. They must be carefully watched to prevent leakage of gas and are condemned by fire insurance companies.

The use of electricity has added many new varieties of lighting fixtures as well as duplicating those used for candles, oil lamps, and gas. Portable lamps may be attached to a light flexible cord, which is often concealed in the standard and can be connected with a floor or wall socket at will.

Types of Oil Lamps

Oil lamps are made with either one or two flat wicks, or, in the case of student lamps, with a tubular wick. The oil reservoir which feeds the lamp is usually below the wick but in the student type it is in a cylindrical well at the side. The original student lamp was so constructed that the oil was fed evenly and abundantly to the tubular wick and burned with a clear, steady flame in a tall cylindrical chimney. It was supplied with a porcelain shade green on the upper side

and white underneath which gave a soft, pleasant reading light that has not been surpassed, and seldom equaled, by any other device. The lamp could be raised or lowered at will on the standard which consisted of a base and stiff rod to which the lamp was attached by a screw. These lamps were of German manufacture and are now almost impossible to secure. The "student" lamps now used have two flat wicks placed side by side with an elevated oil well. Double student lamps have a central well and lamps on each side.

Oil lamps can be made into electric lamps by merely putting an incandescent bulb in place of the wick and attaching a cord at the side or running it up through the base.

Adjustable Lamps

Adjustable lamps are so constructed that they may be turned in various directions, as well as raised and lowered on the standard. Floor lamps have wood or metal bases and are conveniently placed behind a couch or chair with the light exactly where it is wanted.

Table lamps of this type may be used to advantage at a dressing table or in a library. By turning the shade upside down they will give indirect lighting. Small adjustable lamps are made to fasten on the backs of chairs or bedposts for the benefit of invalids or for those who like to read in bed. "Gooseneck"

lamps have a flexible standard which permits many different adjustments.

Lamp Chimneys

Lamp chimneys protect the flame of a lamp in the same way as the sides of the lantern or the bell around a candle. The usual shape for a lamp chimney is a shape between that of a cylinder and a cone cut off at the top. It is larger at the base than near the top, but not so large in proportion as the base of a cone. The Argand or student lamp chimney is a straight cylinder with a collar or projection near the bottom.

Lamp chimneys must be well annealed or they will break when heated. They should never be damp when the lamp is lighted since a drop of water will cool the spot it touches and result in breakage.

Lamp Stands

Lamp stands or bases may be of wood, metal, pottery, or glass. Beautiful ones are made from bronze and porcelain vases by piercing the side or bottom of the vase to admit the cord, and adding a lamp socket and shade frame to the top.

Floor lamps have standards of plain mahogany or of gilded and painted wood in French and oriental designs which are sometimes very elaborate. They are also of iron, bronze, and brass or of metal painted in

enamels. Adjustable floor lamps have very plain standards.

The less expensive standards for either floor or table lamps are made of a composition metal which is poured into bronze molds and sprayed by means of the air brush or spraying machine with enamel and lacquer finishes.

Old ivory is produced by spraying with white or cream-colored enamel and spreading a brown solution over it. In some places the solution is entirely removed and in others only partially wiped off.

A green antique bronze effect is produced by wiping a greenish solution on a copper bronze base.

Very hard water-proof enamels may be mistaken for the metals which they imitate if they are put on skilfully. They are sometimes almost as viscous as glass and can only be applied by the spraying process.

Lampshades

Lampshades may be of metal, porcelain, glass, paper, or textiles in many forms.

Metal shades for reading lamps may be solid with brass or copper above and a silvered surface beneath to reflect the light. The light is too concentrated to be pleasant in a room without other illumination. Metal shades are also made in pierced designs sometimes studded with glass jewels in oriental fashion.

Porcelain lampshades give a soft, pleasant light and are made in almost unlimited varieties, though the green and white are most common.

Glass shades are now usually made either in the heavy semi-translucent opal glass or in iridescent Tiffany glass. The light metal frames in which opal glass is set are usually of composition molded in the desired shape and sprayed with enamel. Curved pieces are heated and bent from flat sheets of glass by the shade manufacturer. Glass domes are of molded or pressed glass. Many of these are painted on the underside and fired in a kiln.

Parchment shades are made of a specially prepared paper which is given a hard leathery finish.

A textile shade having the appearance of painted glass is made of scrim or cheese-cloth, hung loosely on a metal frame and varnished until it shrinks to fit the foundation. It is painted with enamels and when finished has the translucence and brilliant surface of painted glass.

Shirred silk, tapestry, and cretonne are all used in making lampshades. An interesting lamp for a library consists of a bronze standard supporting a bowl lined with mirrors which reflect the light of a high wattage lamp upon the ceiling. Beneath the bowl are three other bulbs to make a reading light, and suspended from the top of the bowl is a white lined silk shade

which makes the combination look like a well-proportioned lamp of ordinary construction.

Candlesticks and Candelabra

Candlesticks are also found in the Lamp Department. Besides the glass candlesticks described in Chapter XIV, those of porcelain or bisque, brass, bronze, iron, and wood are found. Porcelain candlesticks are usually simple in shape, being round, square, or columnar with plain bases. They are decorated with gold bands, fluting, and little painted flowers. Some French candlesticks have Watteau figures at the side.

Brass and bronze candlesticks are simple in design unless they are of oriental patterns when they are apt to have dragons coiled around them. Some beautiful Egyptian candlesticks are of pierced brass. Russian brass candlesticks and candelabra have a kind of fretwork ornament.

Iron candlesticks are sometimes very elaborate as wrought iron is soft and malleable and may be fashioned into scrollwork or plant forms which are often graceful and ornamental.

Candelabra are stands or holders for two or more candles. They are made of the same materials as single candlesticks, but brass is the most common material. Russian candelabra with five or seven branches have a somewhat oriental appearance due to

their fretwork ornamentation. Hanging candelabra are also made of hammered brass.

Candle protectors are shaped like an inverted bell with the opening at the top. They are found with brass candlesticks which have a deep broad saucer and ring for carrying, as in an antique bedroom candle. The deep bell covers the entire candle and protects it from gusts of wind. The modern candlestick, bell and all, is a reproduction of the plain Colonial design.

Glass balls and prisms decorate many candlesticks and chandeliers (originally meaning "candle-holder"). Gilt candlesticks and candelabra with marble bases and a row of glass prisms hanging beneath the candle are very bright and sparkling. When the prisms are raised at the side to the level of the flame, the brilliancy is greatly increased. The designs for these are French.

Chandeliers decorated with many rows of balls or prisms are made for use with either candles, gas, or electricity. The light reflected from so many sparkling facets makes the whole fixture shine like gorgeous chains of precious stones. When chandeliers of this type are used in dining-rooms and banquet halls, the latter are given an atmospheric chill because of the coldness of the light. The glass prisms and tears have the appearance of suspended icicles. Light of a red, glowing tone, exemplified by indirect candle light, adds to the cheerfulness and warmth.

Lanterns

Lanterns may be either movable or fixed. They may take the form of either candles, lamps, gas burners, or incandescent lights protected on all sides by a box, or cover of glass and metal combined. Oriental lanterns have jewels of glass inserted in a metal fretwork more or less open.

Lanterns are suspended above or beside doorways and in exposed arches or passages. In the country a lantern is the light for those who travel on foot or by wagon or carriage. For automobiles, lanterns are replaced by the oil or electric lamp with a lens (see Chapter XVI) to redirect the light from the polished reflector and lamp.

Ships' lanterns have cylinder lenses to make the light source appear as a "pencil" of light, by which beam candlepowers are built up. Such lanterns are used exclusively for signals.

Lighting Fixtures

Wall and ceiling fixtures are of many kinds, including the older types of candelabra and lanterns and also many new ones made possible by the use of electricity, which is fast taking the place of all other methods of lighting.

Side fixtures for gas have:

1. An open flame usually surrounded by a glass shade or globe open at the top.
2. An incandescent mantle covering the outlet in order to increase the light per cubic foot of gas burned. These should be protected from drafts by a small glass shell in addition to the outer globe or shade.

Side fixtures for electricity are:

1. Candelabra with porcelain candles and either pointed or round incandescent lamps to represent the flame.
2. Bells or other pendent lights.
3. Lights inserted in the wall and covered with translucent glass.
4. Segments of bowls, molding, or other fixtures which conceal the light from below and reflect it upon the upper wall and ceiling.

Ceiling fixtures for gas are all hanging and only differ in the shape of the fixture, the number of lights, and other details.

Ceiling fixtures for electricity may be:

1. Pendent with visible lights in bells, candles, lanterns, or other forms.
2. Pendent with invisible lights:
   (a) In translucent bowls—semi-indirect system.
   (b) In metal bowls—indirect system.

3. Combinations of the indirect and semi-indirect.
4. Ceiling lights either visible or concealed with translucent glass.

Electric light fixtures should always be characterized by grace and beauty, although many of them are not. The adaptability of electricity has made it possible to reproduce old types of lighting and to create new ones, and the many new methods of treating and decorating glass give a very wide range for originality. Yet we see hosts of ugly designs as well as beautiful ones.

Indirect Lighting

Indirect lighting is secured by throwing all the light rays upon a reflecting surface by which they are diffused over a large space.

The concentrated light of high wattage lamps may be used to great advantage in this way. The ceiling so lighted gives a soft glow which is very pleasant to the eyes.

The lights are concealed in metal bowls lined with mirrors which reflect the light either upon the ceiling or upon white porcelain discs which again reflect it but break up and refract, or turn, the rays so that they are scattered and softened.

Semi-Indirect Lighting

The great objection to indirect systems is that the

light source appears as a black spot on a light ceiling. This is psychologically wrong. Furthermore the maintenance costs are unfavorable.

Semi-indirect or shadowless lights aim to secure the same softness and diffusion with greater light efficiency.

Semi-indirect lights have white or ground glass globes or bowls instead of the metal ones. These "filter" the light rays while the ceiling or disc above reflects and disperses them.

Daylight Glass

Colored articles viewed by daylight may have an entirely different appearance when viewed by artificial light of a reddish character. Cloth or ribbon carefully matched for color by artificial light may not match at all when viewed by daylight. Thus there is a demand for artificial daylight for color matching. Very few realize what is demanded to produce artificially a light similar to that emitted from the sky.

It has been known for a long time that in daylight there are certain proportions of all the different colors in the visible spectrum. Upon analysis of the light emitted from our most modern lamp it has been found that the greatest per cent lies in the red end of the spectrum, while very little of the blue is present. If we surround such a light with a glass which functions

as a selecting medium, transmitting red, green, and blue light in the same proportions that appear in daylight and absorbing the rest, we will have a so-called "daylight glass." This glass when viewed in daylight has a bluish appearance because it transmits all the blue, absorbing some of the green and a large percentage of the red.

To produce a true artificial daylight in this way, efficiency must be sacrificed, since the light from the red end of the spectrum, forming about 80 per cent of the whole, is in part absorbed by the daylight glass and is therefore a total loss. Consequently this ideal reproduction of daylight is never sought. In daylight lamps, Mazda "C2," 75 per cent of the light from the filament is transmitted by the glass. In daylight illuminating glassware about 40 per cent of the light from the filament is absorbed, while in local color-matching units, the glass reproduces daylight more nearly, and therefore is still more inefficient than the two preceding. When color-matching glass is used, 12 watts per candle produce the same illumination as 1 watt per candle without the glass.

History of Lamps

The use of lamps is very ancient, though the ancient lamp would be a poor substitute for the modern one.

The type found in Grecian ruins and seen in old

drawings was a sort of shallow pitcher with a spout or nozzle at one end for the wick and a ring or flattened projection at the other for a handle. In the middle was a hole through which the oil was poured. Sometimes there were several holes for wicks. These lamps were made of terra cotta or of bronze. They were often decorated and also made in fantastic shapes. Only vegetable or animal oils were used, none of which were so satisfactory as the modern petroleum. Wicks were of twisted or plaited strands of flax or cotton.

Lamps were also suspended by chains. They were similar to the hand-lamps in shape and material, but the decoration was on the under side. Lamps burning incense were used in temples and at shrines.

The words "candle" and "lamp" are used interchangeably in the Bible. There were no candles of the modern type and candlesticks were really lamp stands. The seven-branched golden candlestick of the Jewish tabernacle had seven lamps at the ends of its branches.

The simplest form of portable light was the torch which consisted of a long pole, the end of which had been dipped in pitch or covered with some other inflammable and slow-burning material.

Lanterns are also of very ancient origin. The earlier ones were covered with horn, bladder, or oiled paper, which was more or less translucent. Chinese and Japanese paper lanterns have been very popular in

Europe and America because of their gay colors and sometimes fantastic shapes. The Japanese Feast of Lanterns is one of the most brilliant and beautiful of national festivals.

The discovery in 1853 of a method by which petroleum or coal oil could be refined and used for lighting made almost as great a change as the invention of the incandescent light. Before that time, animal and vegetable oils, especially sperm oil from the sperm whale, were used for lamps and lanterns.

Illuminating gas began to be used in 1802 and the incandescent gas light in 1826. The incandescent electric lamp was invented by Edison in 1879. It consists of a bulb containing a thin platinum wire which becomes incandescent when an electric current passes through it.

Chapter XVI

OPTICAL GLASS

Requirements of Optical Glass

The behavior of glass toward light rays is not only the source of its beauty but makes it one of the most useful of all materials. The optical properties of glass magnify the range and power of human sight when used in the telescope or microscope, and correct defects in vision when used in eyeglasses or spectacles. We can hardly imagine the modern world without glass lenses.

The requirements of optical glass are so much more rigid than those of ordinary types that it must be made of exceedingly refined materials fused in special furnaces, with scientific exactness at every stage of the process.

The value of optical glass, especially for large lenses, depends upon its transparency, freedom from color, and homogeneity. Glass which we are accustomed to call "transparent" really absorbs a considerable amount of light, as we may see by looking through several sheets of window glass placed together. When this glass has a decided color, such as a greenish tint, it absorbs still

more light. Now for tableware or window glass this tint may be overcome by using decolorizing materials, such as arsenic, cobalt, or manganese (see pages 9 and 16), but these do not really take out the color; they only neutralize it and they limit still further the transparency of the glass. Therefore they cannot be used when transparency is so important. The original materials must be as pure as it is possible to make them.

Veins or Striæ

Homogeneity, or "sameness," is of the greatest importance in optical glass. In order to understand this we must remember that glass is not a simple substance, or even a solid compound substance, but a mixture of several materials which have hardened while in a viscous state. During the processes of melting and fining, these materials are not distributed in exactly the same proportions all through the glass, and the result is that even the clearest "plate," if looked at from the end (through its greatest thickness), will be seen to have veins or striæ running through it where the mixing has been imperfect. Any alumina or other impurity which the hot metal has absorbed from the crucible, even though so small an amount that it could only be discovered by a chemical analysis, will also cause these streaks or veins.

They are practically invisible in glass of ordinary

thickness but they are a serious defect in optical glass, because they deflect the rays of light. The most persistent experiments and laborious processes have been used to eliminate these veins.

Furnaces and Crucibles

The manufacture of optical glass is an exceedingly expensive operation. First the furnaces must be small, containing only one or two pots, since they need constant attention. The crucibles are made of specially prepared refractory clay and heated for several days in a kiln near the furnace.

When the pot has reached the proper temperature it is taken up on an iron fork and quickly transferred to the furnace. The opening is then bricked up, leaving only the hole through which the materials are to be introduced and the pot is heated still further. Finally, just before the glass materials are poured in, a small quantity of cullet of the same composition as the glass which is to be made, is thrown in and allowed to melt. This makes a glass coating over the fire clay and prevents impurities from becoming absorbed by the new glass batch.

Materials

Materials for optical glass must be pure and finely pulverized in order that the melting and mixing shall be

perfectly even. For special purposes many new materials are used such as:

Hydrated oxide of alumina (instead of silica)
Barium nitrate
Zinc oxide
Boric acid
Flourine

The proportions of the materials are also varied to such a degree that there is a long list of glasses to suit every optical need. There is, however, great danger in altering the chemical composition of glass because it can easily lose its power of resistance to attacks by acids or alkalies. Some of the finest optical glass will become blurred in a very short time if exposed to dampness or even to the atmosphere.

Manufacture

The materials are put in the pot very slowly as they boil up at first and the air bubbles must all be expelled. When the pot is full it is closed except for a hole through which the "stirrer," usually of fire clay, is introduced. This stirrer is kept in constant motion in order to make the mixture uniform until the process of fining is complete. It is then sometimes withdrawn, but is often allowed to remain bedded in the hardening glass.

The glass is cooled as rapidly as possible without

chilling any one part more than another; after the cooling has reached a certain point the pot is placed in an annealing kiln and the process continues more slowly. Otherwise the glass would fly to pieces.

When cold the fire clay is broken off, sometimes leaving a solid mass but more often the glass has been cracked and falls into a number of pieces. These are not equally clear and some are rejected at once. The best pieces are pressed into iron molds and heated until they take the form of plates, discs, or blocks. When cooled polarized light is passed through this greatest diameter (where two faces have been ground flat and parallel) in order to detect striæ. The entire batch may yield not more than 20 or 25 per cent of perfect glass and large pieces are much rarer than small ones. The cost of large lenses is therefore much greater in proportion to their weight.

Jena Glass

Modern optical glass was revolutionized by the experiments of E. Abbe and O. Schott, two German scientists who established a laboratory and works at Jena. In 1885 they received a grant from the government, and with this aid were able to perfect their processes until Jena glass became the recognized standard for the world.

One of the serious handicaps to the Allies in the

Great War was their inability to obtain Jena glass for range-finders, periscopes, field glasses, and other optical instruments. Before the war closed England, France, and America were making optical glass declared to be as good as that of Jena.

American Optical Glass

In America the demand for the rapid production of field glasses and other instruments for the army and navy has led to a method of cooling which is less wasteful and expensive but produces a less perfect glass.

The process of melting and fining is the same but the contents of the crucible is carefully poured out on a slab, as in rolled plate, instead of cooling in the pot. The bottom and sides of the pot are chilled in order to keep the temperature even and the sheet of glass formed in this way is less likely to splinter and crack than the thicker mass. No part of this glass is entirely free from striæ but they are so slight that the glass will serve equally well for many purposes. Photograph lenses, spectacles, and field glasses are made from this glass.

The annealing of optical glass is a very slow process. It is done in kilns and takes from five or six days to a number of weeks.

Lens-Grinding

The grinding of all lenses is a tedious process, but

large telescope lenses are so extremely difficult to make that only a few men in the world have been entrusted with them. The greatest lens-making astronomer in the world was the late Dr. John A. Brashear who ground the lenses for the Yerkes and Mt. Wilson observatories. The Yerkes telescope at Williams Bay, Wisconsin, is the largest of its kind, the lens being 40 inches in diameter. At Mt. Wilson there is a lens 72 inches in diameter, and in Canada one 100 inches in diameter, weighing 2¼ tons, but these are both mirror lenses in which minute defects would not be fatal. (See Chapter IX.)

For panoramic sight, the surface of a lens must be correct to 1/100,000 of an inch. French periscope lenses were practically perfect, as they must be to photograph the flight of a cannon ball. All photographic lenses must be exceedingly accurate.

Lenses and Prisms

Lenses and prisms are shaped so that they will change the course of the rays of light which pass through them. Lenses have curved surfaces which bend the light rays, and prisms have plane or flat surfaces which are placed so that they turn the light rays and at their edges break up the white light into the colors which compose it.

Lenses may:

1. Magnify or produce an image larger than the object, as in a microscope.
2. Reduce the size of the image, as in a photographic camera.
3. Bend all the rays into a "pencil" of light, as in a lighthouse.
4. Collect heat and light rays, as in a burning glass.

Without lenses and prisms we should have no telescopes or magnifying glasses, no spectroscopes, or even eyeglasses to correct defects in human sight.

Spectacles or eyeglasses may be either flat, colored glass merely to protect the eyes from light or to conceal deformities, or they may be an aid to defective sight.

For correcting defective vision, prisms and spherical and cylindrical lenses are used. Prisms correct double vision. Spherical lenses are:

1. Convex, to correct "long sight" (hypermetropia).
2. Concave, to correct "short sight" (myopia).

Compound and cylindrical lenses are useful in correcting various forms of defective eyesight.

These lenses are commonly made of crown glass (see page 155) or rock crystal pebbles.

Opera glasses and field glasses are small telescopes with two or more lenses so adjusted that they magnify

objects at a distance and seem to bring them near to the eye. Crown glass or rolled optical glass is used for these lenses as the striæ are invisible unless the lens is viewed edgewise.

For compound lenses or other union glass it is necessary to have glasses of exactly the same coefficient of expansion. To test this the glass is blown in concentric balls with one glass interior and the other exterior. If the outer one expands less than the inner it will crack and split off. The glasses are then reversed and the experiment repeated.

Laboratory Glass

In chemical or physical laboratories, glass is an indispensable material. Jars, tubes, retorts, and crucibles are made of it because of its transparency, cleanliness, and relatively great resistance to the action of chemicals.

It is corroded by strong alkalies, but the only acid which has a noticeable effect upon it is hydrofluoric. It is also a non-conductor of electricity which makes it an essential part of electrical equipment.

For laboratory use, however, even the slight effects of chemicals on ordinary glass are serious drawbacks in making experiments and the danger of breakage either from shock or from sudden changes in temperature has caused scientists to try new combinations of materials in order to overcome these defects.

Laboratory, as well as optical glass, was developed with the greatest success in Germany at the Jena factory which became the center of the world's supply. When the supply was cut off by the Great War other countries began to make experiments of their own.

In the United States five or six new factories were soon started in order to fill this great need and much of their product has been passed by the Bureau of Standards by which all glass made for laboratory use must be tested. Seven tests are given in the following order to determine the resistance of the glass:

1. Water
2. Mineral acids
3. Carbonate alkalies
4. Caustic "
5. Ammonia and salts of ammonia
6. Heat shock
7. Mechanical shock

Resistance to chemicals and heat is even more important than to mechanical shock, such as dropping or striking, which may be more easily guarded against.

Some of the materials used in these new glasses are rare and expensive and the process of manufacture requires much more care than ordinary glass. Their future development in this country may depend on some sort of government support, such as the Jena manufacturers have had.

Thermometers

Thermometer tubes are made of blown glass drawn out very fine. One of the characteristics of viscous glass is that it will retain the shape given to a tube by the blowing process no matter how finely it may be drawn. If the opening is triangular in the beginning it will remain triangular and not become round.

Clinical thermometers, for use in testing fever temperatures, have a triangular tube, so small that the mercury cannot be seen except when the instrument is held in certain positions and will remain suspended until shaken down.

The white line seen in the tubes of some thermometers is made by flattening a cake of white enamel on the side of the bubble of glass and dipping them together into the molten glass again. When "drawn" the enamel follows the line of the tube. (See Chapter XII.)

Chapter XVII

WINDOWS AND WINDOW GLASS

Kinds of Glass Used in Windows

The glass used in windows may be:

Sheet glass
Plate glass
Rolled plate
Figured rolled plate
Polished rolled plate

Sheet Glass is blown in cylinders 5 feet or more in length. These cylinders are split open and flattened out in a kiln. The glass is graded according to its freedom from wavy lines, air bubbles, and other defects.

Plate Glass is made by grinding and polishing the best quality of sheet glass on both sides in order to remove the wavy surface.

Rolled plate is made by pouring the glass out upon a flat surface and rolling it. Rough cast plate is not transparent, but the surface may be polished like sheet glass.

Figured rolled plate is made by means of rollers with engraved surfaces which press a pattern into the glass before the metal has hardened. Rough and figured rolled plate is used for glass screens and for skylights where transparency is not desired.

Polished rolled plate is much heavier than sheet glass, ranging in thickness from 3/16 of an inch upward. It is used for large panes, such as those in shop windows.

Window Glazing

Window glazing, the art of setting glass, has evolved the following forms of windows:

Double-hung
Casement
French
English casement
Leaded lights

Double-Hung Windows

The windows to which we are accustomed in modern houses are made in two sashes, with or without a central bar dividing the panes of glass. These sashes are hung in the window frame on pulleys with weights at the end of each cord to balance the sash, which may be raised and lowered with ease. In country houses may be found windows which have no weights and therefore

require spring bolts which slip into holes in the frame and hold them at certain heights.

In double-hung windows the glass is set by the glazier in a groove near the outside of the framework of the sash and made secure with putty or cement pressed down around the edges on the outside. When the cement has hardened the window is also waterproof.

Casement Windows

In spite of the greater convenience of the double-hung windows, the older casement type is considered more artistic for many styles of architecture and has now come into quite general use. These casement windows are swung on hinges like doors and are made of small panes of glass, sometimes set in a framework of wood, sometimes leaded, that is, put together with strips of lead either in simple squares or diamonds or in fancy patterns.

French Windows

French windows extend to the floor like double doors. They often open on porches, but sometimes only onto an iron grill on the outside of the base. French windows may have a single narrow pane of glass. They are characteristically high and narrow.

English Casement Windows

English casement windows are broad in proportion to their height with high sills and are usually grouped two or three in a row. When the framework of these windows is of wood it is made in the factory in the ordinary way, except that it has additional cross-pieces and smaller panes.

Leaded Lights

When window glass is set in lead the construction is not quite so simple. The lead for these windows is drawn by hydrostatic presses into long strips with a cross-section like the letter "H." (For metal drawing, see "Housefurnishings Manual.") There are over a hundred varieties of lead strips but all of them have a similar cross-section with two broad pieces or "flanges" connected by a narrow "heart." The width of the flanges ranges from 1/8 to 1 inch and the hearts also vary according to the thickness of the glass to be inserted. The hearts are sometimes made of steel to give greater stiffness, but the lead is then much harder to bend and manipulate.

A window made of leaded lights is glazed on a flat table or bench. Two strips of lath are first placed so that they form a perfect right angle, and are securely fastened. This angle serves as the corner from which the window is built up. The leads are then straightened

in a small vice and the flanges are opened with a wooden tool to admit the glass. If the latter is cut in squares or diamonds the glazing is done with long straight pieces of lead running perpendicularly or at the same angle with the line used as a base and short pieces of equal length for the intersecting sides. In elaborate patterns the leads may need a great deal of bending and manipulation, requiring the skill of a trained craftsman.

When the glass has been placed in position it is secured with bench nails until the leads are applied, then another row is built in the same way. Finally the outer leads are laid on, two more laths are nailed against them, and the joints are all soldered on one side. It is then carefully turned over and soldered on the other side and a cement made of white lead, linseed oil, and putty is brushed into all the cracks and joints to make them water-proof.

Kinds of Glass Used in Leaded Lights

Colorless glass appears as:

Crown glass, which is made by a spinning process and is in the shape of discs about 4 feet in diameter marked with concentric, wavy lines. The heavy centers of these discs are called "bull's eyes."

Rippled glass, which has a wavy surface.

Embossed, engraved, or etched glass (see Chapter VII).

Brilliant cut, on plain or frosted surfaces.

Beveled and figured glass.

Colored glass may be:

Pot metal color, either solid or streaked by dipping the blow pipe into pots of different colors and working them together.

Flashed glass (see page 106).

Opalescent glass (see page 103).

Antique glasses.

Color may also be applied in the form of:

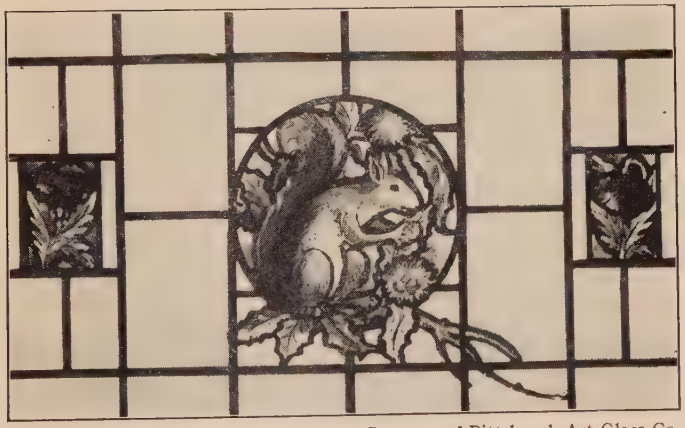
Painted enamels and

Silver stain.

All of these colors are described in connection with the treatment of stained glass.

Colored glass is used in mosaic patterns with the figures opalescent but studded with jewels of transparent color. A medieval fashion has recently been revived, consisting of transparent leaded panes with small unsymmetrical, painted insets representing scenes, heraldic devices, or other symbols.

Much of the domestic painted or opalescent glass is raw in color, ugly in design, and inappropriate to its setting. The poor quality of the glass and the crude designs have brought it into disfavor as the barest



Courtesy of Pittsburgh Art Glass Co.

Figure 11. Leaded Glass

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simplicity is better than decoration badly done. There are, however, many opportunities for beautiful work, entirely suited to its setting. Uncolored leaded glass of simple pattern can hardly go wrong, but when color or pattern, or both, are added they must be handled with taste, some knowledge of color and design, and, if possible, an acquaintance with the history and development of glass decoration.

Figure 11 is a good example of domestic leaded lights, simple in treatment.

History of Window Glass

To our comfort-loving minds one of the most important uses of glass is in windows where its transparency or translucency admits light into our homes while shutting out the air. In warm climates this is not so important, however, and we therefore find no evidences of the use of glass for this purpose in the Far East or in Egypt, though it was set as jewels or ornaments in their brass or stone work.

There are remains of glass windows in the ruins of Herculaneum and Pompeii and those of Roman villas in Britain, but only the very rich could afford such a luxury. The openings in medieval castles were closed with wooden shutters and covered with draperies, but in the homes of burghers in the towns, glass was gradually introduced. In the ninth century glass was used

in churches and domestic fashions seem to have followed the ecclesiastical ones except that the treatment was simpler, and more transparent glass was used.

The finest domestic glass was made in Switzerland in the seventeenth century. This glass consisted chiefly of small panels exquisitely painted in miniature with enamel colors. Miniature painting on glass became the national art of Switzerland, where it held its own for a century after it had been lost or degraded in the rest of Europe. Picture panels which were made for wedding gifts or exchanged by trade guilds are now preserved in museums, especially the one at Lucerne. The favorite subjects were the exploits of the family or their coats of arms, which had become exceedingly elaborate in the seventeenth century. Some of our modern houses have revived this use of coats of arms in hall windows where the bright colors are at least pleasing to the eye, whether anybody knows what they mean or not.

For many years the makers of window glass were interested only in perfecting their processes and developing a clear, flawless glass, but the time came when artists condemned this mechanically perfect glass as entirely lacking in beauty. Windows made with such material were only transparent squares in the wall to which they added no charm either of color or form.

Stained Glass

All glass colored in the batch might be called "stained," but the term "stained glass" is usually understood to refer to the glass found in church or memorial windows. The art of stained glass includes design as well as material.

There are at the present time several conflicting theories concerning this form of art glass, which can be fully appreciated only by artists but are of interest to everyone interested in glass. The men and women who have the choosing of church windows should be able to distinguish between the different styles, even if they are not artists.

The three types of modern stained glass windows are:

Enamel-painted
Opalescent
Antique

Sometimes all three are to be found in one church, giving a unique effect, but not one to be commended. The enamel-painted window is the one most widely used, but it is believed by many artists to be a passing style. The two other types are the result of efforts to treat glass in a more characteristic way, but they proceed in almost opposite directions, differing not only in the treatment of the glass but also in the effects sought.

Enamel-Painted Windows

Enamel-painted windows have been the generally accepted type since the seventeenth century and have no clear theory of glass design. They are made of colored glass pieces separated by lead lines, but, except in simple, geometrical patterns, the leads are not of great importance.

The more elaborate windows are heavily painted with enamels, that is, with metallic paints mixed with a flux to make them adhere to the glass. The effects sought are similar to those in other paintings and the artists have learned the painter's technique. Sometimes, in order to give the desired perspective, deep shadows and heavy masses of color are used, which make the glass practically opaque.

Eminent artists have painted these pictures and the designs are often beautiful, but they are not true "glass pictures." They suffer from the use of a method which belongs to pictures intended to be looked *at* rather than *through* and they do not bring out the beauty of the glass.

Opalescent Windows

Opalescent, or Tiffany, windows are the result of many experiments made by the artist, John La Farge, and further developed by Louis C. Tiffany, who tried to create a new art of glass, stained in the batch instead of being superficially painted (see page 119).

The material is very beautiful, with an exquisite blending of colors, delicate shading, and iridescence produced by the combinations of rich, metallic oxides and remarkable effects of line and form made by the skilful manipulation of the glass in its molten state. (See Chapter XIII, "Tiffany Favrile Glass.")

Antique Glass Windows

Antique windows are the result of a study of the early art of stained glass. They are made of transparent colored glass and are therefore nearer the enameled windows than the opalescent, but the only pigment used on them is peroxide of iron without a flux. This is sometimes replaced by peroxide of manganese. If the former is used it gives a brown shading while the manganese is black but no new color is added by either one. They only serve to give detail to the picture outlined by the leads and to lower the light. According to an old proverb, "The glass worker's palette is his glass."

Antique Glass

The making of stained glass like that of the thirteenth and fourteenth centuries has been considered one of the lost arts, because glass of such richness and variety of color and depth of tone was supposed to have been made by processes of which the secret had been lost.

This is not the fact. The beauty of the old glass was not due to secret formulas. On the contrary its variety of color and texture was largely the result of imperfections in the glass! The modern, commercially perfect glass with which we are familiar is too uniform for the glassworker's purpose.

The old, crude methods of manufacture were most uncertain as to product. The various metallic oxides produce different results at different furnace temperatures and sudden variations in temperature will have strange effects.

Air bubbles and impurities were the result of crude methods of fining and variations in thickness were due to other limitations. We do not know whether the old glassworkers appreciated the value of these imperfections which were sometimes serious enough to mar the beauty of the metal, but often had the opposite effect. Air bubbles or dust when seen against the light became prismatic, refracting the rays of light like the inner facets of jewels and giving to the glass a crystalline quality which it ordinarily lacks.

Streaks of color, clouded effects, and uneven thickness were variations which added much to the possibilities of the color scale and the craftsman of that day added to these unsought variations the mixing of colors on the blowpipe, flashing the metal from one pot on that of another, and other devices for producing the effect

he wanted. His greatest allies, however, were the lead lines which gave to each of his strong, pure colors its greatest intensity and to the whole picture its wonderful brilliancy.

Reproductions of Antique Glass

When artists began again to use the strong lead lines and to aim at true glass technique, they also tried to reproduce the metal of the old craftsman. In this effort they have been more than successful. It is now possible to get air bubbles and streaks and cloudiness by scientific methods instead of depending on accident.

The best antique glass is of English manufacture. It is all made by hand and each successful variety has back of it many costly experiments. For this reason the maker must have the promise of support in his venture and thus far the United States has not given this promise. Windows in this country are a combination of the flat-toned domestic and imported antique glass, the latter being used for the more brilliant effects.

Antique glass is usually blown in cylinders and then flattened into sheets 24 inches long and 16 inches wide. One variety called "Venetian" is blown into a mold having a screw pattern on the inner surface. While still soft it is removed to another mold having the screw pattern running in the opposite direction so that the

intersecting lines produce lozenges which are used as jewels.

Color is flashed on a colorless base, as in ruby glass, which is always made in this way, or it may be on another color, gold pink (made with gold oxide) being flashed on yellow, blue, or purple to make certain very brilliant colors.

A glass similar to the antique, called "Norman slab," is colorless, or, rather, a greenish white. It is blown into a mold shaped like an iron box, which chills the metal so quickly that it spreads over the mold very unevenly, producing a wavy appearance like water.

The Making of Stained Glass Windows

Like architecture, with which it has a very close connection, stained glass is both an art and a craft. It begins with the design of the artist, but it ends with the very practical art of glazing. Windows are openings through which a building is lighted and therefore should be wind-proof and rain-proof, but not light-proof, as some unfortunately are.

The process of constructing a window involves many minor operatons. These may be grouped as follows:

1. Making the small colored design. For picture windows there are two additional stages in this first process:

(a) Making figure studies
(b) Drawing large cartoons

2. Making the large "cut line" drawings indicating the position of the leads. The sections of these drawings are all numbered.

3. Cutting out the sections with pattern shears, which are three-bladed, leaving a space for the leads.

4. Laying each section on glass of the color desired and cutting the glass with a steel wheel (instead of a diamond as it was formerly done). For enamel-painted windows only the ground color is needed. In antique windows the pieces are smaller and there is great care taken to choose those of exactly the right texture and color gradations. For opalescent windows the choice involves not only color but lines and suggestions of form, as the picture is to be a glass mosaic. If the right effect is not secured by the first choice the glass may be "plated," with one piece on top of another.

5. The pieces are next assembled on a glass easel for the purpose of completing the design. They are temporarily attached to this easel with wax.

6. Enamel-painted windows are now ready for the completion of the design. As the different colored enamels are not of the same composition they do not "fire" at the same temperature and the heat necessary to fuse one color on the glass would melt another one completely. They must therefore have the harder

enamels put on and fired first and the softer ones later.

Antique windows are painted in a similar way except that the pigment is without variation of color or flux. The method, however, is quite different because the effect is to be flat. The design is worked over several times, always with iron peroxide, called "antique brown."

First, the outlines are drawn in with the pigment mixed with French fat oil and turpentine. The whole design is then stippled over with a soft badger brush, the pigment being mixed with water and gum arabic. This is rubbed down to give shading and high lights, the glass is given a coating of coal oil and the design again strengthened and softened by the application of the pigment ground in oil of tar and coal oil. Both hard and soft brushes are used, some of them very finely pointed and with handles having sharp metallic points with which the color may be cut away.

Some of the best work is a combination of etching and painting. Flashed glass is used which has the upper layer cut away in certain places, exposing the color beneath and this coat may be further varied with a coat of silver stain.

Silver Stain

This is the one true stain used on all kinds of stained glass. It is made of a solution of silver which gives

the glass a beautiful series of yellows from a pale, greenish shade to a deep orange, without destroying its transparency.

Opalescent glass also must have certain features painted, such as the faces, hands, and feet of persons in the pictures, but it cannot be fired without losing its play of color and iridescence.

Firing

Glass was formerly put in a muffle or closed kiln for firing, in order that it might be protected from the fumes and smoke of the fuel. Small gas furnaces are now used. The best kilns are tunnel-shaped, about 8 feet long and 3 feet wide, with an arched roof 2 1/2 feet high in the center. The glass rests on an asbestos-covered tray on each side of which is a series of gas jets which may be turned on and off either separately or at the main key.

Firing in a gas kiln takes from half an hour to an hour and a half. If the results are not satisfactory the process is repeated.

Glazing

Glazing is the final assembling of the window. Two straight pieces of wood are placed at right angles on the glazier's bench and securely fastened, forming the corner from which the window is to be put together.

The leads are stretched and straightened and clipped into suitable lengths and the outside leads are laid against these laths.

The working drawing is placed on the board and, row after row, the glass is set in place with leads between. At intervals pieces of wire are soldered in which are afterwards twisted around tie bars.

The antique window designs need the leads which are of several different widths, some of them quite broad. The glass in these windows is in small pieces, and if the leads were not part of the design they would mar it.

In the painted windows the leads are not an important part of the design, and in the opalescent they are still more inconspicuous.

When the assembling is completed the joints are coated with oleic acid and soldered on both sides. Finally a cement made of white lead, linseed oil, and putty is brushed into the spaces between the leads and the glass and worked down into the cracks until the window is water-proof.

Stained glass windows assume one of two following forms:

Lancet, high, narrow, and pointed at the top like a lance.

Rose or circular.

The windows may be divided into sections by stone mullions.

Effect of the Finished Window

The beauty of a stained glass window is very much affected by its location. Those which are to be placed nearly on a level with the eye can be given delicate treatment, but those to be seen at a distance must be given bold lines or the design will be weak and blurred. The lines are not only softened by distance but the light which shines through the glass is refracted so that it narrows even the leads. Work which may seem harsh and crude on the easel is only strong and well defined at the proper distance.

The effect of light is all-important. Windows with "hot" colors should not be on the south side of the building to receive the glare of a summer sun, but against a cool, gray light. The brilliancy of adjoining windows and the lights which will fall across the picture, must also be considered.

The artist who is to design the window should always see its setting. Otherwise he cannot know all of these points. Drawings and photographs may indicate the architecture of the building, but cannot give an idea of color and light.

Stained Glass Design

Enamel-painted and opalescent windows are alike in one respect. They are intended to look like pictures. Rounded forms, shadows, and perspective give one the

sense of looking through the window at a scene beyond. The pictures are often beautiful, but they are not architectural in design, as wall decorations should be, and they sadly obscure the light.

In this respect the opalescent glass is an even greater offender than that which is painted in enamels. The large quantities of metallic oxides and the creases and ridges which look so like drapery or landscapes are too heavy to be translucent. These mosaics are seen at their best only when there is a cross-light or when the building is otherwise illuminated than by the windows.

Antique windows are not paintings in the ordinary sense, that is, they do not attempt the painter's effects of perspective. The strong leaded lines enclosing their fragments of color give to the artist a material which is quite unique. Not form or even color is the basis of this art, but light.

The designs in antique windows are not massive even when the space to be filled is a large one. One of the unfortunate features of the massive designs sometimes seen is that they dwarf their surroundings. By keeping the designs small, the apparent height of the window is increased. Grisaille (or grayish) windows have a background of silvery gray with suggestions of green, blue, or amber, and medallions of more intense colors set against it.

The glass worker's pigment is used to intensify the

Figure 12. A Stained Glass Window

The Captain Simpkins memorial window. Church of St. John the Evangelist, Beverly, Mass., designed and made by Charles J. Connick

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effects of light and color even more than to outline the pattern. It is heaviest near the leads, lowering the tone of the light and preventing its refraction across them. From the leads it shades off gradually to a point of greatest clearness and brilliancy near the center of the glass.

On the other hand the design itself is almost in silhouette; the shadows are indicated by differences in color tone rather than with pigment.

In Gothic architecture the leads are often but a continuation of the stone traceries in which the windows are set and the painted outlines have the effect of a finer series of leads, while each piece of glass is treated in such a way as to bring out all its color values.

Since windows are usually seen at a considerable distance the color makes its impression before any design can be seen. If the distance is great the design may not be clearly seen at all, the window is only a group of color spots or color masses.

In one modern Gothic church the most beautiful window is behind the organ where only a suggestion of its design can be seen. But no person can enter the church without having his attention arrested by the shafts of intense blue light, like blue fire behind the silver gray organ pipes.

Figure 12 is an example of a lancet window with the

background in grisaille and the central figure and the side panels in rich but clear colors. The lead lines form a part of the pattern. In the small panes are symbolic pictures.

Part IV—The Glass Industry

Chapter XVIII

HISTORY OF GLASS-MAKING

Wonders of Glass-Making

"Among the discoveries due to chance and perfected by man's intellect, the invention of glass is certainly one of the most important. Two examples taken from two extremes of creation, the infinitely great and the imperceptibly small, will sufficiently prove this — the telescope, which brings the heavenly bodies within the range of the astronomer's study, and the microscope, which may be said to be still more useful." [1]

Glassmakers of Egypt

The ancient Egyptians were workers in glass as they were in pottery and many other arts.

The first evidence of the domestic use of glass is found in the frescoes of Thebes, and on some of the earliest tombs glassblowers are represented. Many remnants of Egyptian glass, all beautifully iridescent with earth-made colors, have been found also in ruins

1 Wonders of Glass-making. Sauzay.

of buried palaces which have been excavated.

The Egyptians made many articles of a deep, transparent blue glass, using it for small vases, mosaics, beads, imitation stones, scarabs, bracelets, scent bottles, and charms. Less often they colored their ornaments with pale buff, deep green, and in rare cases with red. Sometimes the piece was decorated with bands of white, yellow, or turquoise blue, and in some instances the whole surface was colored. Birds in mosaics are said to have been represented with such accuracy and delicacy of detail that each separate feather of wing and tail could be easily distinguished. In the British Museum is a human-headed hawk not exceeding three-fourths of an inch in its greatest dimension. Other examples characteristic of Egyptian skill in the art of glass-making are specimens of beautiful glass jewelry found in Memphis and now at the Salle Historique at the Louvre, and a yellow glass scent bottle with the name in blue glass. In the British Museum is an exquisite little blue and orange glass bottle bearing the name of Thothmes II (eighteenth dynasty, about 1590 B. C.); and in the Bulak Museum is an elaborate bracelet found in the tomb of the mother of one of the kings of the eighteenth dynasty. It is formed of microscopic gold, red, and blue glass beads, strung on fine gold wire in a symmetrical design of triangles.

Theban Works of Art

Some of the cups of varied colors found in Thebes show great skill in what may be called glass-porcelain, usually in blue or green. Both the molding and the cutting of glass were also practiced there, as shown in figures and ornaments cast in a mold, and in vases and beads engraved in various designs.

Glass of Other Oriental Countries

Glass was also made in India and in China, but the Indian glass was very defective and Indian methods were primitive. The Chinese probably copied the methods of the Phoenicians, but most of their glass was in imitation of precious stones.

Assyrian Workmanship

Quantities of small glass articles, such as amulets, were early exported from Egypt to Assyria. The Assyrians understood the glazing of pottery and did much of it, as we learn from their ornaments and their glazed architectural bricks. The first specimen of their glass was a vase found in Nineveh, inscribed with the name of an early king; while a greenish glass bowl found in 1852 bears the name of Sargon (722 B.C.) — that is, in the eighth century B.C. This vase is now in the British Museum. It is supposed to be the oldest

specimen of transparent glass yet discovered; as those from Egypt appear to belong to a period earlier than the sixth or seventh century B. C. The Sargon vase was blown in one solid piece and then hollowed out and shaped by a turning machine. Two larger vessels of alabaster were found with it and all were probably used for holding ointment or perfume. A rock crystal lens was also found, supposed to have been ground on a lapidary's wheel and to have been used as a magnifying glass. Blue glazed pottery, glass bottles, and other vases of elegant shape, some of them decorated in gilt, were unearthed at the same time.

Persian Glassware

Persia also produced some beautiful glass, specimens of which may be found in the British Museum and other collections; but Tyre and Sidon were the cities most celebrated for glass-making.

According to an old legend, sailors from a Tyrian ship carrying a cargo of niter, went on shore to eat. Finding no stones upon which to place their pot, they set it upon blocks of niter, and used seaweed for fuel. When the fire died down they discovered that the niter had melted and, fusing with the sand and the ashes of the seaweed, had made glass. Whether this story is fact or fable, it is certain that the glass fac-

tories of this enterprising group of merchants were noted up to and during Roman times.

Sidon is said to have invented glass mirrors and to have known the value of manganese in making glass clear.

We know that Phoenician citizens used the blowpipe and the graver.

Characteristics of Grecian Glass

Greece, which excelled in pottery, paid little attention to glass-making. The Greeks in Rhodes produced glass vessels, such as small bowls of clear crystal and harmonious colors. Bottles of opaque blue or green decorated with gold have been found in Grecian tombs. As a rule the Greeks preferred the blue or crystal glass. Grecian articles of glass must, however, have been largely imported, since there is no trace of the manufacture of glass on Greek soil.

Roman Glass

The Romans used glass extensively for domestic and architectural purposes and also for personal adornment. Factories were established as early as the first century A.D. The emperor Nero was a great lover of glass and an enthusiastic collector, and by his example stimulated the rich Romans to pay extrava-

gant prices for glass, crystal, and murrine (a costly material not definitely known) vases to use on the table at their banquets. Through the encouragement of the royal families there was also much luxurious extravagance in toilet and perfume bottles; the Roman ladies and their slaves carried their own toilet apparatus to the baths. Mourners gathered their tears in tear-bottles hardly one-half inch in height, and placed them beside the ashes of their friends; and also poured wine and milk from fancy bottles on the funeral pyres. Some of these funeral and tear-bottles may be found in the Louvre. Other bottles supposed to have been intended for presents are engraved with the picture of a heart and the word "Amor." Beautiful color effects were obtained from the use of green, blue, purple, amethyst, amber, brown, and rose, in both opaque and transparent glass; some eight or ten shades of blue varying from lapis to turquoise were known.

Varieties of Glassware

There were also many styles of design for the glassware, including perfume, cosmetic, and funeral bottles, drinking cups, flasks, bowls and other vessels, dice, mosaics, small ornaments, and especially imitation stones; the latter were often carved as intaglios and cameos, or set in beautiful filigree work. Cinerary

A—Amphora B and C—Ampullas D—Vase

Figure 13. Examples of Roman Molded Glass

urns were used. Roman ladies carried glass balls to cool and whiten their hands, changing the ball as the glass heated. At banquets slaves poured wine and water from large carafes or decanters into the drinking cups of the guests.

Glass was blown, molded, pressed, and cut. The crystal glass made by the Romans was clearer and stronger than that of the Egyptians, and so like the real or rock crystal as almost to defy detection.

In Figure 13, A shows a violet-colored Roman amphora — a tall two-handled jar — which was used to hold wine or oil. The surface has decayed and has the iridescence found in most ancient glass. It is encircled with a series of horizontal alternate narrow flutings and ribbons.

Figure B portrays an ampulla, a vase used to hold perfumes and oil. It is made of opaque light blue glass much decayed, molded in relief, and ornamented with an amphora, a diota (two-handled cup) and other vases placed between six columns supporting pointed arches. Near the base are bunches of grapes and festoons.

Figure C gives an illustration of another ampulla. It is of light green glass with the surface divided by projecting lines into 6 compartments containing in relief an amphora, a syrinx (Pan's pipes), a patera (a

shallow bowl or cup used for pouring libations), and crossed scepters; above these compartments, the vessel is fluted.

Figure D represents a vase of dark glass much decayed, upon which a human face is molded in relief.

Glass of Pompeii and Herculaneum

Both these cities have yielded varied and splendid examples of Roman glass now stored in the Bourbon Museum of Naples and elsewhere. More than four thousand such articles have been collected, among them the Naples and Portland vases discovered in a tomb in 1644 and placed in the British Museum. The Portland vase is always referred to as the most beautiful known specimen of the glass engraver's skill. It was at first supposed to be carved from a precious stone, but on closer inspection it was found to be made of a dark blue glass with exquisite cameo-like figures which are carved out of a superimposed layer of opaque white.

Varieties of Bottles

Among the Pompeiian relics are numbers of square glass bottles in which housekeepers kept their wine, oil, vinegar, honey, etc.; some of these bottles are a foot and a half high, while there are hundreds of smaller bottles of other types. There are glass plates

fourteen inches across. A fragment of one patera made of a blue glass that is as splendid as a sapphire, with milk-white cameos on it, representing a twig of ivy leaves enclosing the head of a ram, suggests Pliny's words, "They sculptured glass more delicately than silver."

Other Glassware

Glass cups, called Christian glass, in colored designs, are also found among the relics of the catacombs of Rome. The subjects pictured are religious, such as the Nativity and the raising of Lazarus. Some of the cups have purple in the draperies, green in the sea waves, and pink in the faces, while the more ornate specimens are decorated with silver, gold-leaf, and powdered gold. Little crystal glass fish are also found, together with vases supposed to have held sacred oils.

Venetian Glass

Very little is known of glass manufacture in Italy immediately after the fall of the Roman Empire, as the industry almost died out with the removal of the government from Rome to Constantinople. Some Italian refugees, during the invasion of the terrible Huns under their leader Attila, fled to Venice, where the industry was kept alive. Among these refugees were glassmakers, who about the fifth century started

the industry, which was soon to become one of the most extensive and world renowned in the history of glass-making. The marine alkali-yielding plants and the abundance of sand about Venice had, no doubt, much to do with the rapid development and the beautiful products of the Venetian glassmakers. But the Venetians also utilized foreign commodities. Boats were sent to Syria to collect the white sand for which their glassware was celebrated, and special woods were brought from great distances.

The Emperor Constantine had taken expert glassmakers to Constantinople, but the fall of that city in 1204 drove many Greek workmen back to Venice with their new recipes to enrich the industry. The Venetians guarded their secrets with the greatest care. If any workman carried his skill to another city he was ordered back and his relatives were imprisoned until he came. Glassmakers were highly honored and many of them were given the rank of nobles.

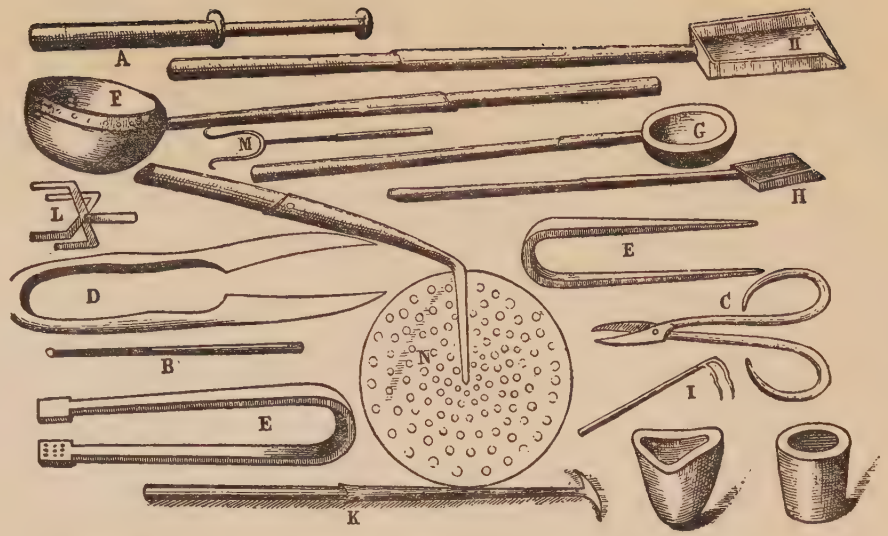
Figure 14 shows an ancient Venetian glass furnace with the glassblowers at work, and Figure 15 shows the tools used.

Murano a Famous Glass Center

In 1291 fear of fire drove the council to pass laws abolishing glass furnaces within the city, and the glassmakers were driven to the lagoon island of Murano, a

A—Blowpipes B—Glass Pots C—Working Holes

Figure 14. Ancient Venetian Glass Furnace



A — Blowpipe. B — Rod for Taking up Glass. C — Scissors for Cutting Glass from Blowpipe. D — Shears for Cutting, Shaping, and Opening Large Glasses. E — Finishing Instruments. F — Large Ladle for Dipping out "Metal." G — Small Ladle for Skimming "Metal." H — Shovels for Handling Glass, Coal, and Ashes. I — Stirring Fork. K — Rake for Stirring. L — Instrument for Making Vessels. M — Fork for Carrying Glass into Cooling Oven and for Changing Pots in Furnace. N — Great Ladle.

Figure 15. Ancient Glassmakers' Tools

suburb of Venice, which has been a famous glass center ever since. In the early part of the seventeenth century there were three hundred glass manufactories in Murano, and nowhere in the world could their beautiful products be matched. The vases, cups, bottles, and decanters of delicate crystal were prized by kings and often were more costly than if they had been made of gold.

In 1300, Murano artists began to coat plates of glass with an amalgam of tin and mercury, and their mirrors became the standard throughout Europe. In 1436 they began to use color in glass; the earlier products were clear crystal with a greenish or violet tinge.

Murano made the most beautiful beads, tableware, bric-a-brac, and the beautiful brown glass flecked with brass filings known as aventurin. Their glass was soft so that it could be spun, woven, or fashioned into the daintiest designs, and they also understood that the reheating of glass added brilliancy; a single piece, it is said, was heated as many as fifty times. To the Murano artists, with their extreme delicacy of taste and touch inherited from their ancestors, coupled with endless study of their art, may be ascribed a fame which eclipsed that of any other glass-making center in Italy, so that for a long time Venetian glass enjoyed a monopoly. In recent years there has been a revival of the skill of the Venetian craftsmen.

Development of Art in Other Countries

The development of glass-making in France, Germany, and England in the seventeenth and eighteenth centuries had an injurious effect on the industry in Murano. The invention of flint glass was a serious blow to the industry, as flint glass is soft and heavy and suitable for cutting, while the light, thin Venetian ware cannot be cut. Glassmaking in Murano declined during the eighteenth century to such an extent that of 300 factories only one remained in the early part of the nineteenth century.

The modern renaissance of Venetian glass is due to the efforts of C. Pietro Biguglia (1845) and later of Salviati, who revived the old processes and invented others, and practiced them with freedom and fine artistic instinct. Backed by English capitalists, Biguglia reproduced old forms of Venetian glass and exhibited it at industrial expositions with conspicuous success.

Spanish Glass

Numerous traces of early glass furnaces are found in Spain, a result no doubt of the spread of the industry from Rome throughout her provinces. Small jars, cups, phials, thickly molded saltcellars, tear-bottles, and bracelets found in tombs suggest home manufacture of them in the valleys of the Pyrenees. Much of the glass of Barcelona (1324) bears a resemblance

to the old Venetian glass and seems to have been made both for home and export use. Many beautiful examples of Spanish glass are found in the South Kensington Museum.

Bohemian Glass

During the sixteenth century glass-making in Bohemia became a recognized industry, when goblets and tankards of white glass with colored coats of arms, millefiori (see Chapter XII), and other decorated glass were made in its factories. In 1609 Casper Lehmann invented engraving on glass and the ancient art of cutting was revived. In 1679 ruby glass was introduced, and the action of hydrofluoric acid on glass, which made etching possible, was also discovered or applied in 1670.

The industry developed rapidly during the seventeenth and eighteenth centuries. Bohemian glass was not so delicately fashioned as the Venetian, but it was of purer materials and therefore clearer; the engraved glass of Bohemia was very beautiful. Flashed glass (see Chapter XI) was much used, and was most effective when engraved or cut to bring out the contrast of color between the rich ruby or violet and the crystal beneath.

Other Varieties

A potash-lime glass was made by the Germans in

imitation of the Venetian, but the colorless variety has always been known as Bohemian glass.

Toward the end of the sixteenth century skilled rock crystal cutters from Milan advanced the art rapidly in the crystal and glass cutting factories at Prague, Bohemia.

Early Art in France

France had some glass factories as early as the second century; the imperial factory at Frontencennes was supposedly the cradle of all later factories in Normandy. The glass was of low quality and of a greenish tinge. During the Roman occupation the native industry died out and Roman glass was used instead. The characteristic Roman articles — vases, wine bottles, dishes, etc.— are found, some of them bearing such Latin inscriptions as "Vale" and "Salve." French museums abound in specimens of this Roman glass which has been unearthed in their districts.

By 667 A. D., foreign workmen, particularly Greeks and Romans, began to revive the industry.

The city of Poitiers abounded in wood and other materials, and ruins of ovens and melting pots mark sites in its districts where glass was made.

Normandy was the first province to grant privileges to glass workers. In the tenth and eleventh centuries

noble families followed the art, and "gentlemen" from Normandy went to establish factories in other cities. In the time of St. Louis it was fashionable to use glass on the table.

While the Eastern countries excelled in mosaics, to the French belongs the distinction of superior work in glass painting and stained windows. Painted glass windows are said to have originated in the School of Limoges about 800 A. D., at which time a Venetian colony was established there. The casting of plate glass was discovered about 1693; blowing was employed up to this time,

The town of Baccarat in France has since 1765 been the center of plate glass and crystal factories which are world renowned. It is one of the three oldest glass centers in western Europe. The people of the district all work in the factories as their ancestors have done for generations, and produce a glass of great beauty and delicacy. In 1823 D'Artiques established in this town the world renowned "Crystalleries de Baccarat."

Many European palaces and public buildings are decorated with panel or plate mirrors, crystal glass cases, lamps, and vases of Baccarat glass. The factories excel in cut and engraved pieces, light and deep rock crystal, and glass with rich ornamentation in gold. One odd and interesting feature is the glass which is

decorated with paintings on opaque foundations to resemble porcelain.

English Glass

The records of ancient glass-making in England are meager. The Druids had rudely shaped colored beads which they used as charms and which they probably obtained in trading with the Phoenicians, who went to Britain for tin. Most of the glass found in tombs and recovered cities is Roman, however, as it resembles that of Rome, France, and middle Europe. Among such relics are beads, vases, and balls of crystal glass, tear-vases and bottles six or eight inches square. Glass must have been plentiful even in Saxon times, judging from the quantity found. The oldest painted windows in England are those of Canterbury (1174), which date from the Norman period.

Glass tumblers and ale and beer glasses were in use on the tables at banquets. In a drawing on an Anglo-Saxon calendar in the British Museum, seated figures are shown drinking from glass cups or elongated tumblers of hornlike shape and blown very thin.

Importation rather than home manufacture seems to have been encouraged.

Growth of the Glass Industry in England

In 1677 the Duke of Buckingham brought glass-

makers from Murano to Lambeth, England, to make crystal vases, looking-glasses, and other articles. In 1685 political disturbances sent French glassmakers to England, so that in 1696 there were 88 glass factories making chiefly bottles, mirrors, and ordinary flint glass tableware.

The distinction of perfecting lead or flint glass belongs to England, as does also the development of the art of glass cutting. Lead glass was much softer and more sparkling than the lime crystal used by the Germans and the Bohemians, and the English cut glass soon surpassed any that was made on the continent. London, Bristol, Birmingham, Belfast, Dublin, and Glasgow became important glass-cutting centers.

The finest specimens of English glassware belong to the period between 1780 and 1810. Nearly all of it was tableware. Stemware of all kinds, tumblers, decanters, saltcellars, pitchers, and mugs in almost endless variety are now gathered by the collectors of this fine type of glassware. Some glasses were thin and delicate, while others were heavy enough to pound the table without injury when this was the custom.

Characteristics of English Glass

English glass shows marked individuality. Bristol glass is especially prized; but all of it is interesting and most of it is beautiful. From the many "baluster"

stems and plain bowls of the earlier types, to the fine cutting, engraving, and trailed decoration of later manufacture, one may trace a clear line of development. Certain peculiarities, such as " tears " or bubbles of air which are found in earlier stems, are developed by a process of drawing out and twisting into the mysterious air twists of later specimens.

This old glass has the clear ring of the lead crystal and much of it is beautifully colored. Greens, from a clear apple-green to the deep color of the emerald, deep sapphire blue, amethyst, and old rose may be found among these old glasses. Political history is also written in the Jacobite pictures and symbols with which some of them are engraved.

English tableware lacks the delicacy of the Venetian and the fanciful decoration of the Bohemian glass, but it is wonderfully satisfactory for its purpose.

Chapter XIX

THE GLASS INDUSTRY IN THE UNITED STATES

Early Experiments

The American colonists made a number of attempts to produce glass, but for various reasons they were unsuccessful. A few English glassmakers came to Jamestown in 1608 and tried to start a factory, and early records mention some Italian bead-makers. Wheeling had several small glass houses in its early history, and Pennsylvania launched several enterprises but all were shortlived. There was a lack of skilled workmen and the sand used was of inferior quality.

There was no general development of the industry until about the middle of the nineteenth century. The glass that was produced before that time was poor in quality and crude in style. The better grades were imported from England, and only such articles as common bottles and heavy table glass were of American manufacture.

About 1840 attempts were made to produce some

decorative ware. Bottles were made in sapphire blue, emerald green, claret, and other brilliant colors; some were shaped like log cabins or cider barrels, and the American eagle or the stars and stripes were used as patriotic decorations for tableware. Opal glass was fashionable for candlesticks, drawer handles, and similar articles.

Pioneer Glass-Making Concerns

The foundation of the glass industry was laid near Boston when the New England Glass Works was established, and for many years Boston led in the manufacture of flint and colored glass of all kinds.

The first furnace had six pots and forty workmen, but in 1865 five furnaces, of ten pots each, were operated, five hundred workmen were employed, and glass valued at $500,000 was produced annually.

Through the enterprise and liberal policy of this company, factories for making glass were also established in other parts of the country. Workmen were brought from abroad, and capital was freely expended to make the industry permanent.

In 1855 William L. Libby, who was then a confidential clerk of one of the large glass importers located in Boston, bought the glass factory of his employers and for twenty years enjoyed an enviable reputation in the Massachusetts industry. Realizing the necessity of

cheap fuel, however, he moved to Toledo, where first natural gas and later petroleum were available. The Libby Glass Company of Toledo, one of the largest of the United States glass manufacturing concerns, is the result.

Another notably successful plant was started in 1852 by Christopher Dorflinger of Brooklyn, with a capital of $1,000, for making glass for lamps and chimneys. The discovery of petroleum at that time had created a great demand for lamps, and his furnaces increased from one with five small pots to four in 1861 and fifteen in 1865. During that year he moved his factories to White Mills, Pennsylvania, where he now operates one of the largest manufactories of cut glass.

Growth of the Industry

The growth of the glass industry in the United States has been due to:

The development of pressed glass.
The invention of the automatic bottle machine.
The improvements in furnaces.
The use of oil and gas for fuel.

Pressed Glassware

The manufacture of glass by means of metal molds was practiced to some extent in England and America as early as 1834. The idea of pressing the molten

glass into the required shape by means of a metal core or plunger was suggested by a carpenter in Sandwich, Massachusetts, and taken up by the New England Glass Company with successful results.

The perfection of this type of glassware was achieved by a Pittsburgh company which took the first prize for fine pressed glass at the Paris Exposition in 1867. The goblets and wine glasses produced by this company could hardly be distinguished from those made by blowing and cutting.

Pressed Lime Glass

Until 1864 pressed glass was always made of flint or lead, with potash and saltpeter, which made it nearly as expensive as cut glass. In that year a Wheeling glass company experimented with bicarbonate of soda and lime, and succeeded in making a clear, brilliant glass at about one-third the cost of the lead glass.

The use of this lime glass caused a rapid growth in the pressed glass industry in the West, and a corresponding loss to the flint glass manufacturers of the East, who could not compete with the western product on account of its lower cost of production. This resulted in the disappearance of many eastern glassworks.

Invasion of Foreign Markets

The purity of color and the excellent design of

American pressed glass, together with its comparative cheapness, has made a market for it not only at home but also in foreign countries, both in Europe and South America.

The Owens Bottle Machine

Another discovery which revolutionized the bottle-making industry was the invention and perfection of the Owens automatic bottle machine. No hand operations are necessary except the oiling and care of the machine. It makes bottles of all sizes and shapes, and the saving of labor is enormous. In 1914 between sixty and seventy of these machines were in use.

Improvements in Furnaces

There were no important changes made in the types of glass furnaces used until 1870, when increased competition led to improvements by which less fuel was made to produce more heat. Larger furnaces were built, many of them holding from thirteen to fifteen pots, which sometimes contained two tons of glass each.

The use of natural gas for fuel gave the Middle West its greatest advantages over other sections of the country; and it is there that the glass industry now has its center. There are, however, several important manufacturing centers in the East, among them Mill-

ville and Glassboro, New Jersey; and Bridgeton, White Mills, and Philadelphia, Pennsylvania.

In the Middle West

In western Pennsylvania, Carbondale is a center, West Virginia and Ohio have many plants, and Toledo, Ohio, makes large quantities of pressed glass as well as superior blanks for eastern cut glass factories.

Muncie and Gas City, Indiana, are important centers.

Alton, Illinois, has the largest flint bottle manufactories in the world, 4,500 workmen being employed. Chicago and some small towns in the neighborhood have numerous plants for manufacturing and cutting.

Pittsburgh, Pennsylvania, is the greatest glass manufacturing center in the country. It produces almost every type of glass. In 1887 the Pittsburgh Plate Glass Company began the creation of what is now the greatest plate glass works in the world.

Pennsylvania leads as the glass-producing state, with West Virginia second. The large deposits of white siliceous sand in the latter state, as well as the abundant supply of coal and natural gas, have caused the rapid growth of the industry.

Today the United States leads the world in the manufacture of glass and glassware. It imports some European art glass and glass for lenses, but exports

greater quantities of machine-made glassware and a large amount of cut glass.

As a result of war conditions, the trade in glass between this country and South America has been greatly increased, as well as the orders from European markets. American machinery has been installed in many foreign glass manufacturing plants.

America imports glass from Austria Hungary, Germany, France, England, Belgium, Italy, The Netherlands, Sweden, and Japan. In Belgium glass-making was considered the national industry before the war.

Chapter XX

SUGGESTIONS TO SALESPEOPLE

Qualifications for Selling Glass

The selling of glassware requires taste, intelligence, and imagination on the part of the salesperson. While its beauty always attracts shoppers, the great variety of styles and designs is confusing. Also most people fail to appreciate the quality and suitability of glassware with the same discrimination which they show in choosing clothing and other practical articles.

A knowledge of the composition of glass, of the difference between lead glass and lime glass, and of the reasons for the greater cost of lead crystal, will often sell the more expensive article. A few remarks regarding the manner in which metallic oxides produce color by fusing or firing make an interesting point; and even the " ringing " of a crystal goblet with its silvery tone adds to the value and attraction of the article.

Manufacture

The process of melting, fusing, and forming glass is like a fairy story to those who have not heard it.

Blown glass, for instance, has a new interest for customers when they learn how it is made. Thus a knowledge of the various processes of manufacturing the different kinds of ware is an essential part of the commercial information of the salesperson.

The salesman should understand the difference between cut, semicut, and pressed ware; acid polish, fire polish, and polishing on wheels. Etching, engraving, and carving should also be clearly understood, as well as the difference between needle-etching and plate-etching. Then the various methods of applying color and gilding are not only interesting but important, because of the greater durability of certain forms of decoration. Articles for mere ornament need not be so durable as those which are to be in constant use. It is therefore less unfortunate to have a vase with a decoration which will soon wear off than it is to have water glasses with the same defect.

Other Points of Importance to Customers

An acquaintance with modern trade centers, both foreign and American, will give interest and authority to a salesperson's statements. Thus the distinct characteristics of Venetian, Bohemian, Baccarat, and Bristol glass have greater meaning when arguments can be based on definite information.

Design is of special importance in glassware, and a

cultivated taste is first of all necessary that one may be really helpful to the customer. Then, a knowledge of the particular designs belonging to any one period, such as the Colonial or the Jacobite, will be serviceable in aiding her to make a suitable choice. The names of the designs, especially in cut glass, should be learned and properly applied as they always attract attention and interest. The exclusiveness of a design gives it an added value to many customers, while standard patterns of recognized merit will appeal to the more conservative.

Suitability

It is estimated that two-thirds of the cut glass sold is intended for gifts. Thus the salesperson may often make a return or an exchange unnecessary by learning something of the purpose for which the article is intended and the possible tastes of the person to whom it is to be given. These must often be mere guesses, but any clue may save some blunders. Thus, when a gift is to be made to one who " has everything," something of an exclusive design is more likely to please than a commonplace article which is likely to be a duplicate.

Then, too, if tactful suggestions are made, gift buyers may select more expensive presents and be better satisfied, because they feel that they have the right

thing; while on the other hand some who have spent less than they had anticipated are thereby made permanent customers.

Arrangement

Glass is usually arranged in as effective a manner as possible, so that its decorative value may be thoroughly appreciated. Single pieces as well as sets may, however, suffer from their surroundings and not be seen to the best advantage. It is often wise to place them in a corner where they have no more brilliant neighbors to dull their beauty; or perhaps there may be pieces which will actually help to set them off. The value of proper surroundings is nowhere more evident than in a Glass Department.

Care

The glass on sale in a department should always be spotless and shining. The salesperson may give helpful information to customers as to the care of their purchases.

Cleaning

The washing of glassware has much to do with its beauty. Glass is slightly acted upon by alkalies; therefore strongly alkaline soaps or washing powders

will dull or scratch the surface. Water at the boiling point will also affect the polish.

Glasses or pitchers which have contained cream or milk should be rinsed with lukewarm water softened with a little soda before being washed with the other pieces, as otherwise all the glass will have a clouded appearance. Water bottles or pitchers which have a deposit of lime on the inside may be cleansed by putting in tea leaves, covering them with vinegar, and shaking the bottles. A teaspoonful of hydrochloric acid in a little water will also remove this deposit. The bottle should be rinsed immediately.

Carbonate of ammonia causes flint glass to become brittle so that it will easily break and pieces will fall off.

Glass should be washed in clean, warm (not hot) water, with a little white soap. Some housekeepers believe that it is cleaner when rinsed in water which contains no soap; others rinse in slightly soapy water and dry and polish on hot towels.

Glass is often broken by pressure from the dish cloth or dish mop when washing the inside. The following suggestion is a good method for delicate cups or glasses:

"Have enough water in the dishpan so that when the glass or cup is turned upside down it will be en-

tirely full of water; now lift the glass quickly, still keeping it upside down and being careful not to tip it. It will remain full of water until it reaches the surface, when the rushing in of air will force the water out so suddenly that it will carry all food particles with it. This is an excellent method for washing sherbet and lemonade glasses." [1]

A writer in " Crockery and Glass " gives the following suggestions for cleaning cut glass:

" First make a warm soap-suds and wash the pieces with an old tooth-brush which will fit into the curved shapes and cut figures. Rinse in clear, warm water and wipe with a linen towel. After this polish with a warm towel and set in a box of sawdust for a few hours. The sawdust absorbs the moisture in the incisions not reached by the towel, and also heightens the polish. When taken from the sawdust rub with a piece of tissue paper and the glass will sparkle like crystal."

Things to be Avoided

Glassware should not be arranged in piles as it is heavy and brittle. Pieces are apt to be chipped off, and sometimes the lower pieces in the pile are cracked by the mere weight of those above. Such arrangement is particularly unsuitable for cut glass.

1 From Choice and Care of Utensils, by Ida S. Harrington, Farm House Series No. 5, Cornell Reading Courses.

Glass should be protected against extremes of temperature, such as cold storerooms or overheated chests. Very hot or very cold water, chilled or hot food, may cause it to crack. It should be tempered or warmed before putting in hot liquids, or cooled before filling with ice-cream.

When boiling water or boiling syrups are to be poured into glass, the danger of breakage is lessened by putting in a silver spoon.

Glass is very little affected by moisture, air, or light. Even after being buried in the earth for many years the only deterioration is an oxidation of the surface which shows in iridescent colors as in antique glassware. Therefore with proper care and handling glass may be considered almost indestructible.

Chapter XXI

CLASSIFICATION OF STOCK OF A TYPICAL GLASSWARE DEPARTMENT

DIVISIONS

A. Tableware
   1. Cut Glass
   2. Pressed Glass
B. Toilet Sets
C. Decorative or Art Glass

A — Tableware

1. Articles in Sets
   - Water
   - Grape Juice or Iced Tea
   - Wine, Cordial, Liqueur, Cocktail
   - Sherbet
   - Grapefruit
   - Punch or Lemonade
   - Finger-bowls
   - Berry
   - Coasters
   - Mayonnaise or Whipped Cream
   - Almond or Relish
   - Sugar and Cream
   - Flower

2. Single Articles
   - Pitchers
   - Jugs
   - Tankards
   - Decanters
   - Carafes
   - Water Bottles
   - Cruets for Oil, Vinegar, Catsup
   - Bowls
     - Fruit
     - Punch
     - Salad
     - Berries
     - Whipped Cream
     - Rose
     - Crackers
   - Compotes or Compotiers
   - Nappies
   - Bonbon Dishes
   - Plates
   - Plateaux
   - Trays
   - Ice-cream Platters
   - Sandwich Plates
   - Celery Trays
   - Jam and Marmalade Jars
   - Sugar Bowls
   - Sugar Sifters
   - Sugar Trays
   - Salt and Pepper Shakers
   - Saltcellars
   - Spoon Holders
   - Dinner Bells
   - Toothpick Holders

Knife Rests
Syrup Jugs
Fern Dishes
Punch Ladles
Salad Forks and Spoons
Iced Tea Spoons
Baking Dishes
Ramekins
Cake, Pie, and Bread Pans
Casseroles

3. Materials
   - Sand
   - Lead
   - Lime
   - Potash
   - Soda
   - Metallic Oxides
   - Gold
   - Silver
   - Enamel
   - Rock Crystal

4. Manufacture
   - Cut
   - Carved
   - Blown
   - Pressed
   - Molded
   - Rolled

5. Decoration
   - Etching
   - Gilding
   - Enameling
   - Engraving

Frosting
Painting
Silver Deposit
Body Color
Single Color
Iridescent Colors
Fire Colors

6. Kinds
American
English
French
Swedish
Bohemian

B — Toilet Sets

1. Articles
Night Sets
Guest Sets
Toilet Bottles
Toilet Sets
Puff Boxes
Pin Trays
Comb and Brush Trays
Jewel Boxes

2. Materials, Manufacture, Decoration, Kinds
See 3, 4, 5, 6, under A

C — Decorative or Art Glass

1. Articles
Vases
Candlesticks
Candelabra

Flower Bowls
Flower Baskets
Card Holders
Clocks
Pin Trays
Comb and Brush Trays
Jewel Boxes

2. Materials, Manufacture, Decoration
See 3, 4, 5, under A

3. Kinds
Same as A-6
Venetian
Bohemian
Tiffany

Appendix

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Glass Manufacture, Walter Rosenhain. Van Nostrand, $2
Principles of Glassmaking, Powell. Geo. Bell & Sons (London)
Glass in the Old World, Wallace Dunlop. Field & Tuer (London)
Wonders of Glassmaking, Alexandre Sauzay. Scribner, $1
Laboratory Guide of Industrial Chemistry, Rogers. Van Nostrand, $1.50
The Glaziers Book, E. L. Raes. Maclaren & Sons (London)
English Table Glass, Percy Bate, B. T. Batsford. Scribner, $2.50
Decorative Glass Processes, Arthur Duthie. Van Nostrand, $2
The Lure of the Antique, W. A. Dyer. Century, $2.40
Marietta, Marion Crawford. Macmillan, $1.50
Crockery and Glass Journal, Trade Journal
International Studio, Special articles
J. P. Morgan collection
Development of Cut Glass Industry in the U. S., W. F. Dorflinger
American Glassware, Old and New, E. A. Barber. Keramic Studio Pub. Co., $1
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